MODERN BUSINESS

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Modern Business

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Modern Business

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PLANT MANAGEMENT

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MODERN BUSINESS
VOLUME 4

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PREFACE

In 1903 Mr. F. W. Taylor presented before the American Society of Mechanical Engineers a remarkable paper on "Shop Management". This paper was the first of its kind and the first attempt to formulate what might be called a philosophy of industrial management. The paper met with an instant response and it has done more to quicken the study of this subject than any document of its kind ever written because it raised for the first time in a clear cut manner the query as to whether management was essentially an empirical matter depending upon personality, or whether there were basic facts or principles that could be applied without reference to personal ability.

Without raising the much debated question as to whether industrial management can ever be placed on a strictly scientific basis it appears that there are a number of well-defined principles on which successful management must rest. These principles were all well known long before Mr. Taylor presented his classic paper, but he was the first to present a group of these principles in an orderly manner as a basis for industrial management.

The first part of this book aims therefore to present in a simple manner the methods and principles that men have found to be economically helpful in

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managing industrial enterprises and to explain in a concise manner the origin and background of our present industrial system. It is recognized, however, that while these methods and principles can often be discussed abstractly they can never be applied successfully without taking cognizance of the human element involved. The latter part of the book, therefore, treats largely of those phases of industrial management that involve consideration of the workers themselves. The treatment of all topics is necessarily brief and only such illustrative matter has been inserted as was necessary to clarify the text.

The author has drawn freely from the writings of other workers in this field and an effort has been made to acknowledge such help in the text. Grateful acknowledgment is here made for all such assistance. The author will be thankful for suggestions, criticisms, or corrections that will make the book more valuable or more accurate.

DEXTER S. KIMBALL.

Ithaca, N. Y.

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PLANT MANAGEMENT

CHAPTER I

THE BASIS OF MODERN INDUSTRY

1. *A new industrial day.*—Our own times have undergone, without doubt, the greatest transformations in industrial methods that man has as yet accomplished. Men now living have seen the handicraft arts practically disappear and have seen machine industry, mass production, and factories of unbelievable size take their place. Younger men have known no other condition. To them it may well appear that this complex industrial fabric is fixed, or nearly so, but as change has been the order of the day in the past, there can be no doubt the future holds the promise of further developments. Industrial methods are still in rapid flux and with the kaleidoscopic industrial changes go far-reaching political and social disturbances. The industrial employer who ventures into this turbid sea without some knowledge of these changes and the tendencies which they portend is comparable to the sailor who puts to sea without compass or rudder.

2. *Industrial ideals.*—Ever since man has been upon the earth his first thought has been of his animal

needs, to procure food, shelter and clothes, and to subdue inclement and unfriendly nature. But in all times and in all places even when his bodily wants have been meagerly supplied his mind has instinctively turned to speculating as to whence he came, why he is here, and whither he goes when he departs hence. And as he weighed his bodily necessities against his speculative conclusions he built up what we are pleased to call a philosophy of life. At times industry has occupied only a despised and lowly place in this philosophy, at others it has been exalted to the highest position as man has evaluated differently these two fields of activity. There can be no intelligent discussion of industry without full recognition of this important relation, especially at the present time, since never before have ideals played such an important part in industrial problems. We are interested in industrial problems, as such, but we are more interested in *men* and should never lose sight of the human side in any industrial considerations. The idea that industry should be a means of giving *all* men physical comfort, mental development and spiritual uplift is distinctly an ideal of the present day.

3. *Other industrial systems.*—At different periods and among different races of men industry has been conducted in many and varied ways. Many industrial systems have preceded the present, and we have no guarantee that the present system will be permanent. All preceding systems, however, had one common characteristic. They were all based on *handi-*

craft and handicraft processes. The tools used were comparatively primitive, the worker was the industrial unit, and generally speaking, *congregated* labor was comparatively rare. The skill of the worker was the important factor in production and his tools were an auxiliary to this skill.

4. *The roots of modern industry.*—Institutions once established do not change over night. Revolutions in industry take place slowly. Tho we frequently hear the expression that the invention of a given machine has revolutionized a given industry, there is always much inertia to be overcome. Capital invested in existing plants is not scrapped immediately. Often the older machinery wears out before the newer and improved machines replace it. As time goes on perhaps the speed of replacement increases, but certainly in the beginnings of our modern industrial system steps were taken cautiously and slowly. In this fact we have the reason why traces of the older order remain today, and why a generation ago the old and new seemed still to be in active competition.

We cannot fully understand the problems of modern industry without going back to the eighteenth century, to what historians call the industrial revolution. It was then that the roots of modern industry sprouted, tho the tree has only come to a large fruition in our own time.

5. *The industrial revolution.*—Near the end of the eighteenth century certain machines appeared in the

textile industry of England which were destined to change the course of industry. While primitive when compared with some modern machines, these machines were of far-reaching importance. They required so little skill of hand in their operation that the operator at once became of secondary importance, and his skill of hand merely a supplement to the skill of the machine. The era of machine industry was thus ushered in. Before "The Industrial Revolution," so far as we know, no such industrial methods had ever been used by man. Large machines, some of them fairly complex, had been built long before that time, but in these machines of the industrial revolution the "transfer of skill" from the worker to the machine was so great as to constitute an epoch-making event.

The invention of the steam engine coming about the same period did much to accelerate the growth of the new system. Until that time the size of power-driven industrial establishments was limited by the size of some waterfall. But with this new source of power all limitations from this quarter were instantly removed, and factories immediately began to grow in size.

The industrial changes following the revolution brought many social changes. Political changes followed also in the wake of the social changes. We are not directly concerned here with these matters and will discuss only those changes which pertain strictly to factory organization and management.

6. *Industrial growth of the United States.*—The

industrial progress to which reference has been made is strikingly illustrated in the record of manufacturing growth in the United States, which is found in the census reports. Tho abortive attempts to gather information in regard to manufactures had occurred earlier, the first authoritative information was collected by the census of 1850. At that time the term manufacturing was broadly defined to include any mechanical operations, and in addition to factories it comprised the building trades and hand and neighborhood manufactures. A gross product of half a billion dollars was recorded in 1849 which fifty years later had grown to ten billion dollars. Hand trades and allied operations had come in the course of time to occupy a subordinate place in our industrial production, and since 1904 they have been excluded from the enumeration of manufactures. Of a total product of ten billion dollars they had constituted in 1899 about one-tenth. Now it is interesting to note that the average product of these hand and neighborhood industries in 1899 was $2,600, and to contrast this figure with the average of $4,300 for all establishments in 1849. The factory as we know it today had reached only a slight development by the middle of the last century as the relatively close approximation of these figures demonstrates.

7. *Industrial concentration.*—The large size of modern manufacturing plants is one of the notable characteristics of industry. Growth in this direction seems for the moment to have no limits. Every one

can recall particular factories which in his own experience or that of his neighbors have grown from small beginnings to extensive proportions. These personal observations are confirmed by the official record. In 1904, 79.3 per cent of the manufacturing product of the United States came from factories whose annual product was $100,000 or more, but in 1914 the output of such factories had risen to 84.6 per cent of the national production. Or again we find the record that in 1909 only 14.4 per cent of industrial workers were employed in small establishments with not more than 20 men each, while in 1914 this proportion had fallen to 13.1 per cent of the workers.

8. *Modern industrial problems.*—There can be no doubt then that the distinctive problems of modern industry are those which grow out of the large size of industrial units. There is, moreover, every prospect that these conditions will be accentuated in the future. A clear grasp of what is involved in them is therefore of the utmost importance for all who would understand modern industry or play a rôle in it.

Of the productive efficiency of modern industrial methods there can be no doubt. Nor can there be much doubt that in the long run all men will be benefitted because of them. There are certain aspects of these new methods, however, that often render their extension inexpedient; for apparently no industrial *progress* can be made without some *change* that affects some group of workers adversely. The min-

imizing of these adverse effects is one of the great problems of industrial management.

REVIEW

What is the ideal of the present day with regard to the place of industry in the welfare of society?

What were the characteristics of the handicraft processes?

What was the characteristic feature of the so-called industrial revolution and what effect did the invention of the steam engine have upon the new industrial system?

What, in general, did the term "manufacturing" include in the middle of the nineteenth century?

What adverse effects accompany industrial progress?

CHAPTER II

FUNDAMENTAL INDUSTRIAL PRINCIPLES

1. *Leadership and method.*—The history of the race is filled with the achievements of great men who have attained results, apparently because of their great *personality.* Undoubtedly personality always has been and always will be an important factor in guiding and inspiring men. But the more we study the work of great leaders the more apparent it becomes that these men were also masters of *method.* History for the most part tells us little of the methods of great leaders but lays the greater accent on personality. Generally speaking, moreover, the great leaders who have preceded us took their knowledge of method with them.

Now in industry at least, it has become increasingly clear that while personality is important, method is often of even greater importance. And while it is conceded that no methods of clerical machinery of any kind can ever replace personality, it is also conceded that proper methods may be of great assistance to personality, if indeed they are not indispensable, so far at least as industrial matters are concerned.

During the last twenty-five years, therefore, much effort has been expended in finding, if possible, what

basic industrial principles there are that are not dependent on personality and that can be recorded, thus serving as a guide to all men interested in industry. At the same time great efforts have been made to analyze that vague thing known as personality with a view of placing on record such principles or criteria as will enable us to understand men better, to gauge their ability more accurately and, as a consequence, to fit each man more closely into the position where he may be of greatest service to himself and to the community. The first part of this book deals with the basic principles and methods of industrial management, while the latter part discusses briefly the human side of industry. It may be well, therefore, in the beginning to discuss briefly the abstract principles of industry that are independent, in a way, of all personal relations and which have been proved by long experience to be basic and impersonal.

2. *Transfer-of-skill tools.*—From the beginning man has found it necessary to provide himself with tools of some sort to supplement his skill or strength in his fight for existence. He has often been characterized therefore as "the tool-using animal." Nearly all tools and machines embody the principle known as "transfer of skill." A transfer of skill is made to a tool when the operation to be performed can be accomplished by the aid of the tool with less skill on the part of the operator than if he performed the task unaided by the tool. A drilling fixture or "jig," so called, is an example of this principle. A

skilled toolmaker makes the drilling fixture so that the drill will be guided to the work with great accuracy tho an unskilled man may do the actual work. The toolmaker transfers his own skill to the fixture and his connection with the operation ceases. A man of less skill may do the work if supplemented by the fixture. Until the Industrial Revolution few, if any, machines had been developed in which the accuracy of the machine exceeded the skill of the worker. Since that time the principle has been extended to a marvelous degree. It should be carefully noted that this principle is not peculiar to machines but is applicable to hand production as well.

3. *Transfer of mental skill or intelligence.*—Even tho a machine may embody all the skill necessary for the operation to be performed, the operator must, in general, apply some *thought* to his work. It is possible, however, to transfer intelligence to a machine so that it becomes fully automatic in its operation and independent of any operator. Automatic screw machines are excellent examples of a complete transfer of skill, both manual and mental. The modern player piano is also an excellent illustration. The thought of the composer is transferred quite accurately to the paper record, but the transfer of skill required to produce this thought in musical form is somewhat imperfect. It is interesting to note that composing and playing are not necessarily the accomplishment of any one individual. The industrial field is filled with machines in which the transfer of skill is very complete.

4. *Division of labor.*—The oldest and best known economic principle of production is division of labor. Man discovered very early that by concentrating his efforts, either mental or manual, he could increase his skill in his chosen specialty, and also that he could produce a greater quantity of goods. This principle is so well established as to need little comment. Modern machine production and the great growth of knowledge have carried division of labor to an extreme in some industries.

The term division of labor has from long usage become associated in our minds almost exclusively with the manual processes. But productive labor of any kind is generally both *mental* and *manual;* and just as there can be division of manual labor, so there can also be division of mental labor. Modern industrial methods tend constantly to separate mental labor from manual labor and to subdivide each into smaller and smaller divisions. Just as division of manual labor is facilitated by the use of tools, so division of mental labor is hastened by an increase in the amount of knowledge necessary to perform the work under consideration.

The application of this principle is well illustrated in the organization of practically every productive industry. The conduct of industry is usually divided into four primary activities, namely, producing, selling, financing and accounting. It will be observed that the work of financing, selling and accounting is almost purely mental. Production is again divided

into planning and actual manufacturing, as is well illustrated in the engineering and production departments of manufacturing establishments. This particular separation of the mental and manual labor in manufacturing should be carefully noted, as it is one of the best examples of a complete division of the mental labor of production, so far as planning or design is concerned, from the manual labor of actual production. The trend of modern industry is to extend this principle indefinitely, separating, as far as possible, the mental processes from the manual processes and subdividing each process within itself.

5. *Mass production.*—The principle is well established that, in general, the cost of production can be reduced if the quantity to be manufactured can be increased. This principle follows directly from the two preceding ones. Obviously it will not pay to make an expensive tool if only a few pieces are to be made, unless such a tool is essential to secure accurate results. It is cheaper, in general, where the number to be made is small, to do the work with skilled workmen and with such tools as are at hand.

In a similar manner it is clear that there will be little economic gain in subdividing the operations on a given part and employing several men to do the work unless there is a considerable amount of work to be done in each division. Division of labor, therefore, depends upon quantity for efficient results. If, however, the requisite quantity is to be had, very special and costly tools may be constructed and ex-

treme division of labor may be employed, since the reduction of cost by these means will much more than offset the cost of the equipment. When the quantity becomes very great, as in the manufacture of shoes, watches, typewriters, etc., the reduction in cost that can be obtained by the use of labor-saving machinery and division of labor is enormous. We speak of such manufacturing as "mass production."

6. *Coordination of effort.*—It is axiomatic that if the effort necessary to produce a given result is subdivided by the use of either men or machines, the operations of these men or machines must be coordinated if the result is to be obtained. A football team is an excellent illustration of coordinated effort. Every man must perform his own particular function perfectly and with exact reference to the efforts of his fellow players. Coordination of effort is one of the most difficult problems in factory organization and management. As division of labor is more fully applied and as departments increase in number it becomes increasingly necessary to coordinate the effort of men and departments. The means employed to secure coordination in industrial concerns is broadly termed "system." A more extended discussion of this subject will be made in a later section, but it may be well to note in passing that it may be necessary to secure coordinated effort in a physical manner, as when the several parts of a machine made by different men must fit together properly. Or again it may be necessary to secure coordination of effort in point of

time. Thus, the parts of the machine referred to may be required not only to fit but also to arrive at the point of assembly at the right time relatively to one another.

7. *The use of recorded experience.*—It has already been noted that, for the most part, great leaders of the past took their knowledge of method with them. Indeed it is doubtful if many of them could have recorded their methods in a serviceable manner. It is obvious, however, that the application of any principle or method gains in effectiveness if it is done in accordance with recorded results and experience. This is well illustrated in the work of the engineer. A few years ago the work of this profession rested almost entirely upon personal experience and there was little literature to guide those who had no experience in such matters. Today we have a vast accumulation of recorded experience covering all lines of engineering design and construction. This recorded knowledge is open to all and has resulted in a broader and better understanding of engineering problems.

The use of recorded experience in manufacturing is just beginning to find a place. For the most part manufacturing is still conducted upon a basis of personal knowledge. In a few departments, such as cost-finding, recorded experience is now quite common; but in almost all other departments of manufacturing the records of experience are meager and unreliable. The next quarter century is sure to see a

great growth in the direction of collecting and recording manufacturing data.

8. *The scientific method.*—The importance of recorded results grows directly out of our experience with what is called the "scientific method," by means of which we have done such wonderful things in the fields of pure science. It is important to know clearly what this method is, because it is just beginning to be applied to problems in the fields of management and manufacturing, and there is every reason to believe that we shall accomplish just as much with this method in this new field as has been accomplished in the fields of pure and applied science.

The general laws that underlie any art may be known qualitatively or quantitatively. Thus we all know that beams will bend if loaded. The chemist may know that the addition of a certain acid to a given mixture will precipitate a certain substance. If, however, the knowledge of the chemist and the engineer does not go beyond these generalities their knowledge is qualitative only. The major part of our knowledge is of this general character, namely, that certain causes produce certain effects. The literature of applied science abounds with expressions of this kind, indicating that much work remains to be done in many such fields.

But if the chemist can state that a given quantity of acid will precipitate a definite amount of a certain material from the liquid in question, he is said to know the laws pertaining to the operation quantitatively

and fully. Quantitative knowledge of the laws of any art involves measurement of cause and effect, and it is only when such measurements have been made in sufficient number to show beyond doubt the exact relation between cause and effect that we can say that the laws rest on a scientific basis.

It should be specially noted that when the laws governing any phenomenon of operation are thus fully known, it becomes possible to predict the results that follow. This is well illustrated again in chemical and physical problems. The scientific method of attacking any problem, therefore, is to collect carefully all data bearing on the matter, analyze the data and deduce from them the true laws which underlie the phenomenon, test the results by experimental determinations, and record the entire proceeding. Such recorded information, if accurately obtained, is impersonal or scientific. The application of this method to industrial problems will be discussed in later sections.

9. *Conclusions.*—The basic principles and economic facts discussed in the foregoing are abstract principles and hold true regardless of the human element; tho, of course, the effectiveness with which these principles may be applied depends greatly upon this latter factor. Their influence upon the industrial field during the last century has been very marked and it will be in order, therefore, to consider some of the results that have come about because of them and to inquire into the possibilities of the industrial field,

if they continue to operate, which no doubt they will do.

REVIEW

Compare the relative importance of personality and methods in modern industry.

What is meant by the expression "transfer of skill" as applied to a tool or machine?

Explain what is meant by the division of labor into mental and manual.

How does division of labor affect quantity of output?

Differentiate between quantitative and qualitative knowledge in the field of applied science.

CHAPTER III

CHARACTERISTICS OF MODERN INDUSTRY

1. *General.*—The industrial principles discussed in the preceding chapter are as old as humanity itself. They were undoubtedly applied in a limited measure under handicraft production, but for many reasons their effect was not then so great as it has been under modern methods. Modern industrial methods have greatly accelerated certain tendencies that had already appeared in the old handicraft factories. Some of these tendencies are particularly important in their bearing on industrial organization and management and will, therefore, be briefly discussed.

2. *Increase in size of factories.*—One of the most remarkable characteristics of modern industry is the great increase in the size of factories. A few years ago a factory employing five hundred men was considered a large establishment. One large manufacturing company of the present employs over 20,000 men in one establishment, 15,000 in another and operates several more in which 2,000 to 5,000 men are employed. The tendency for all successful industrial enterprises is to increase in size indefinitely. There are many reasons for this tendency. The large concern can purchase supplies in large quantities,

hence at lower rates. If properly managed, the fixed charges for management, superintendence, etc., will be less, proportionally, than in the smaller factory, tho at the same time the large plant can command the services of the highest grade of men for its administrative positions. The apparent stability and permanence of the large factory assist materially in affording prestige which greatly influences the sales of product.

Factories have also increased in size simply because of the larger undertakings of the present. Ships, locomotives, engines, etc., are all built in sizes undreamed of by our forefathers, and the machinery of production has increased in size accordingly.

But, aside from these reasons, which are obvious, there is the more important influence of the desire to obtain a large quantity of product. As has already been noted, division of labor and the use of labor-saving machinery are greatly facilitated by increased quantity. If the quantity can be increased, therefore, the unit price can be lowered. This desire for mass production is a natural one when it is remembered that industry today is, theoretically at least, on a competitive basis. Lastly, there is the natural tendency for men to combine their efforts whether these be individual or collective. The last decade or two has seen some remarkable combinations of industrial undertakings, either for the purpose of eliminating competition or for the purpose of self-protection. The economic side of such combinations is

discussed elsewhere in the Modern Business Text but the problems of management which these great aggregations present are of prime importance and will be discussed later in this volume.

3. *Specialization.*—A few years ago it was common for manufacturing plants to produce a very wide range of product. Engines, boilers, mining machinery, marine machinery, in fact almost anything in the line of machine construction was built by the same factory. Similar conditions prevailed in other lines of industry. But as the field of industry broadened, manufacturers found that they could compete more successfully by confining their efforts to fewer lines of goods, just as individuals had previously found that they could produce larger and better results by confining their efforts to a narrow field. Today, therefore, the general factory is an exception and the tendency is to restrict the product of any given enterprise more and more.

Several other influences have hastened this tendency. As industry has become more complex, it has become increasingly difficult for any one manufacturer to keep up with the progress of manufacturing knowledge in a large number of lines. As the industrial field increased in size, many specialized industries sprang up which found a field in furnishing auxiliary supplies, tools, etc., that were formerly made by the general factories themselves. These new specialized industries, by combining the small quantity needed by each of many general factories,

secured the quantity requisite for lowering the cost of production far below that of the general factory so far as these specialties were concerned.

Many new industries have come into existence that are necessarily limited in scope because they are either based on patents or perhaps on a chemical process and are not closely related to any other line of production. Cement factories and factories producing commodities made from salt are excellent illustrations of these new types of enterprises. Obviously, such enterprises tend to close specialization of both machines and men.

When, however, a manufacturing enterprise grows to a very large size a curious reversal of this general tendency toward specialization may occur. In such a case there may come a time when some article or tool that has been purchased from some outside source is needed in such large quantities as to warrant the manufacturer in producing it himself and thus save the profit of the supply man. Thus in the great electrical manufacturing enterprises there may be found plants for producing porcelain products. The General Electric Company, the Westinghouse Manufacturing Company and the Allis Chalmers Company are all large producers of steam turbines. This line of product was developed by these concerns because of the economic advantages so obtained in connection with turbine-driven electric generators. The general tendency, however, of the industrial field is toward closer specialization.

4. *Characteristics of specialized industry.*—Obviously when an industry is closely specialized, the equipment tends to become special also. In the extreme case each machine and each process is necessarily special or it has been adapted to the special requirements from some other field. In an ore-reduction plant, for instance, the machinery is all specially built for that industry, the operations are arranged in logical sequence and each element of product passes thru the mill by the same route and thru the same processes. An arrangement of this kind is known as "continuous process manufacturing." It represents the extreme of specialized industry. At the other extreme is the old type of factory which makes many kinds of articles, but to order only and without any necessary continuity in the manufacturing processes. Fabrication of this kind is often called "intermittent manufacturing" in contradistinction to the other extreme of continuous process production. These two types of factory should be carefully noted. They stand at the extremes of manufacturing processes and as a consequence at the extremes of the problem of organization and management. The continuous process automatically fixes the sequence of operation and the character of the operators. Organization is usually an easy matter in such plants. The intermittent factory on the other hand with endless combinations of product and personnel presents the most difficult problem of manage-

ment. In between come all manner of gradations, some plants having both continuous and intermittent processes.

5. *Effects and dangers of specialization.*—Since specialization is based on division of labor, it will be clear that it possesses the same economic advantages of cheapening and improving the product. Two of its effects, however, should be carefully noted. The first is the effect of specialized processes upon the workman. Necessarily he also becomes highly specialized. While this in the abstract may not be to his disadvantage, it exposes him to two dangers. The first is the danger of having his calling swept away by the rapid changes in the industrial field. This is true not only of the individual worker, but of the specialized factory as a whole. The history of some specialized industries is a continuous record of costly machines thrown out upon the scrap pile, often little used, because of the necessity of employing only the very latest models in order to compete successfully. A highly specialized plant, or a highly specialized man, is constantly in danger from such changes, and for this reason a plant moderately specialized may have an advantage in periods of depression when the failing of one particular part of the market may wreck the highly specialized enterprise.

The second danger to the workman is the narrowing of his work to such a degree that little or no mental labor is required, but only rapid repetitions of man-

ual labor. Such work is, of course, deadening to the faculties and has lately received considerable careful investigation and study on the part of management experts.

6. *Standardization.*—Specialization, it has been noted, is the limiting of an industrial enterprise to a portion of the industrial field and to the production of a limited number of products. Standardization consists of the reduction of any given line to fixed types and sizes. Thus a manufacturer may decide to limit his activities to the production of electric motors. But after that decision is made he must still decide what types of motors he shall make and what sizes of each type. The objective point, of course, is the obtaining of larger quantities. Obviously for a given total number of machines there will be more of each kind if the number of kinds is reduced. Shoes, hats, clothes, motors, engines, and in fact the major part of manufactured goods are now built on this principle. It is sometimes called the method of the average solution, since no shoe, for instance, is now made to fit a particular foot but is an average shape fitting many feet approximately.

7. *Interchangeability.*—Standardization may also be introduced in order to secure interchangeability. We have long been familiar with standards of exchange in weights, measures, currency etc., and with interchangeability in a broad way as illustrated, for example, by standard gauge railways. But of recent years this feature has become closely identified with

manufacturing problems. Interchangeability is desirable in mass production, if for no other reason than that a given manufactured part may have to be operated upon by a series of machines, in which case it is essential that each part shall be exactly like its neighbor in order to fit properly into the several machines. There is a still more important reason, however, namely, the great gain in time in assembling standardized parts as compared with those which vary in form and must, therefore, be fitted together by hand.

It is very desirable, also, that repair parts may be furnished that will fit accurately without adjustment by hand. A most important example of the need and desirability of interchangeability is found in the modern military rifle. The specifications of all leading national war bureaus call for an exceedingly high degree of accuracy in all the parts in order to secure perfect interchangeability. It may be remarked in passing that perfect interchangeability in a mechanism such as the military rifle is very difficult to obtain even with modern machine tools. It will be noted in this connection that the accuracy with which any article can be produced depends upon the accuracy of the tools that are available and this again depends upon the quantity of product that is to be produced.

8. *Standard methods and standard times.*—Generally speaking, it is clear that when a piece of work can be performed in one of several ways, there will be one way that is the quickest and most economical. Such

superior methods may be revealed by a careful investigation of the work and may be adopted as a standard method to the exclusion of all others. It is clear also that if a standard method of performance can be defined, a study of the time required to do the work may result in the fixing of standard times of performance. Later in this volume we shall deal more fully with these conceptions which are rapidly becoming important features in modern factory management under the general title of time and motion study, to the advancement of which Mr. Frank B. Gilbreth has contributed so liberally.

9. *Advantages and limitations.*—Standardization, by tending to increase the total number of parts of any given kind by reducing the variety, tends thereby to lower production costs. By confining the manufacturer's efforts to fewer sizes of product it tends also to the production of a more perfect product simply because of repeated experience. There are also other economic gains that flow from standardization, as for instance the lessened variety of stores that need to be carried. Standardization in general benefits the consumer in that it insures prompt delivery, low prices, interchangeability of product and superior quality.

The greatest disadvantage of standardization is that it tends to crystallize methods because of its inflexibility. This will be more fully appreciated by observing such standards as our weights and measures. A cumbersome and antiquated money system

still exists in England, simply because of the difficulty of changing it. The metric system has certain obvious advantages over the standards of weight and measure in use in this country, but the difficulties of changing seem insurmountable. When a standard has once become firmly established, it is very difficult and usually very costly to change it. This is particularly true in manufacturing where very elaborate and expensive special machinery is often provided for mass production of standardized parts. Standards should be adopted, therefore, with great care, for even tho it be assumed that the standard which has been adopted may be superseded by another more economical standard, there is always the danger that the change will be too costly to make when the superior standard has been developed.

10. *Summary.*—The characteristics of the industrial field that have been discussed in the foregoing sections are the most important factors in modern industrial activities. They have been discussed as abstract matters and their effects have been described as tho men could be moved at will, a condition which no longer exists in industrial countries. These effects have greatly changed the methods under which industry is owned and controlled; they have introduced new factors into the problems of plant location and arrangement; they have modified tremendously our conception of factory management and, more important still, they have affected our entire social and political fabric.

The problems of ownership are fully discussed in the volume on "Organization and Control," of the Modern Business Text. The problems of factory location and plant arrangement will be briefly discussed in a succeeding section of this volume as will also the human side of industry. The chapters immediately succeeding will deal with the problems of factory organization and management.

REVIEW

Why is it that industrial enterprises, when they reach a certain growth, usually depart from their previous plan of specialization?

Distinguish between "continuous process" and "intermittent" manufacturing, and explain the more difficult problem of management in the latter.

What are the dangers of over-specialization both as to men and machines?

What are the chief purposes of standardizing the output in modern manufacturing processes, and what disadvantages sometimes flow from standardization?

CHAPTER IV

METHODS OF ORGANIZATION AND ADMINISTRATION

1. *Departmentization.*—In any small factory or similar enterprise the individual worker is the industrial unit. In such cases the relations between the worker and the employer or foreman are very simple; directions are for the most part verbal and the relations in general quite personal. These conditions were typical of practically all industrial enterprises a comparatively few years ago.

As the number of men in a given plant increases, division of labor necessarily appears and in time there will be more than one man employed in each special duty. The introduction of several machines of one kind may bring about this result. It is perfectly natural when this stage of growth arrives to organize all men performing similar duties into groups or departments for greater ease in administering the work. Departmentization therefore grows naturally from division of labor. It should be noted that an enterprise may be highly departmentized and yet not be efficiently organized, since the basis of departmentization may be faulty. This matter will be dealt with more fully in the section on plant arrangement.

2. *System.*—It has been shown that as division of

labor is applied, it becomes necessary to coordinate the work of the several divided units in order to obtain an economic result. In the early and smaller factories this coordination was performed by the foreman himself, generally by personal direction and without the aid of written documents. As plants have become larger, it has been found that personal coordination is not sufficient and it has been found to be absolutely essential to arrange the relations of departments and men with great care, holding these relations in permanent form by means of written documents of various kinds. Thus the engineering department does not give oral directions to the shop force, but all engineering directions appear on drawings or in some other documentary form. The ways and means employed for administering the work of departments constitute the system.

When the system employed is not correct, it may result in very inefficient work. The system may be so complex and burdensome that results are actually being delayed instead of facilitated. The curse of "red tape," which makes government administration a byword for inefficiency, is unfortunately not unknown in the business world.

Every department as it grows will naturally develop a certain amount of system within itself. Such system will be peculiar to the work of the department and for the most part will depend largely upon the personnel of the department. In the succeeding sections the work of several departments will be dis-

cussed in so far as it bears on general principles of organization, but no attempt will be made to discuss departmental systems in detail, since they vary so widely as to be of great interest to the specialist only. The succeeding discussion will, therefore, be confined to the organization of departments into an economic unit, keeping in mind that a department is a man expanded.

3. *Principles of organization.*—Until quite recently it was widely believed that the art of organization and management was almost entirely a matter of personality. There can be no doubt that personality will always be a large factor in all matters where men must be controlled and inspired to attain a common end; but it is now clear also that there are certain well-defined fundamental principles that can be applied to the organizing of industrial activities. These principles have come down to us as the inheritance of the race and they have stood the test of long experience. In common with all branches of human activity, industrial management will become less haphazard and uncertain as basic facts accumulate and as men build upon these basic facts.

The term industrial engineer has already become synonymous with one who is well informed concerning factory organization and skilled in applying the basic facts and principles to factory management. Such an organizer seeks to rest his conclusions, so far as possible, upon facts rather than upon personal judgment.

While so far as the physical side of industry is concerned, industrial facts are not difficult to obtain, it is very difficult as yet to obtain basic facts concerning the human element involved, tho the modern manager is more and more seeking assistance in such fields of study as economics and psychology. Whether the art of organization and management will ever be scientific in the sense that has been described remains to be seen, but without doubt the old rule-of-thumb methods will be displaced in the near future to a large extent by more systematic and logical methods that rest more upon facts and less upon personal opinion.

4. *Military or line organization.*—The oldest and most natural form of organization is that which is commonly known as military or line organization because it followed the essential feature of organized armies. Such an organization is shown graphically in Figure 1. Here every man is responsible only to the foreman over him, and the foreman in turn is responsible only to the superintendent. A foreman receives neither instructions nor command from another foreman, and the lines of authority and instruction run directly from manager to workman. All men on the same authority-level are entirely independent of any others similarly situated. The character of the work which is assigned to the several foremen is the same tho pertaining to different departments, and the proportions of mental and manual labor assigned to all men on the same authority-level are also about the same. Of course some separation of mental and

manual labor exists, but it comes from the natural reservation of the higher work by those higher in authority and is therefore incidental to the organization rather than the result of deliberate arrangement.

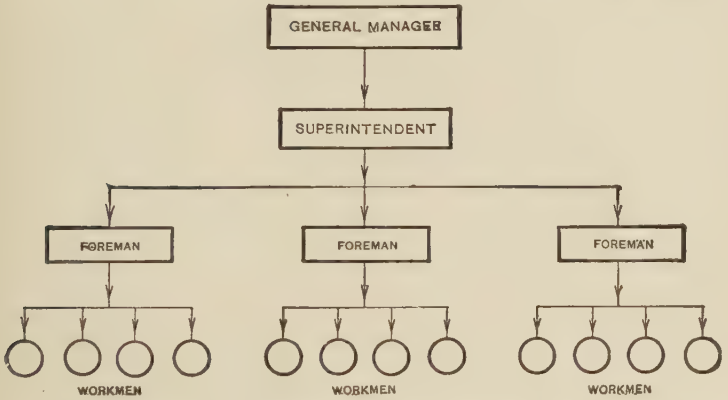


FIGURE 1. MILITARY OR LINE ORGANIZATION

It will be obvious that such a form of organization makes possible rigid disciplinary control. The duties and responsibilities of each and every man stand out clearly and there need be no misunderstanding as to each man's place in the organization. It has, however, some serious defects. The number of executives on any one level is necessarily limited and as enterprises grow in magnitude these executives become loaded up with a variety of duties. This often results in the breaking down of able men because of the great load laid upon them, or in having some of the work poorly performed because of human inability to do many functions equally well. As a conse-

quence, also, the instructions given to the workmen may be very meagre and inadequate, and unless the workmen have great skill and experience the work is poorly performed. The success of any plant organized in this manner is predicated in fact on the presence of highly skilled workers. It will be obvious also that much depends on each executive, and the sudden loss of any one of them may temporarily cripple the undertaking. For these reasons the military system of organization is seldom seen today except in small enterprises and where the work which is being prosecuted is comparatively simple and the need of specialists not felt.

5. *Line and staff organization.*—Pure line organization long ago was found to be insufficient for large organizations, particularly where special knowledge was needed for the successful prosecution of the work. Even in military organization it was found necessary to employ special officers to supervise the commissary, the engineering and other special features of military activities. Thus there grew up what is known as line and staff control.

Such an organization is shown graphically in Figure 2. Here the salesmen, factory manager, accountant and treasurer are grouped under the direction of the president or general manager. The primary division of labor is made on the basis of the functions to be performed and not on the basis of authority. The several staff officers advise the factory manager concerning the general conduct of the factory, but the

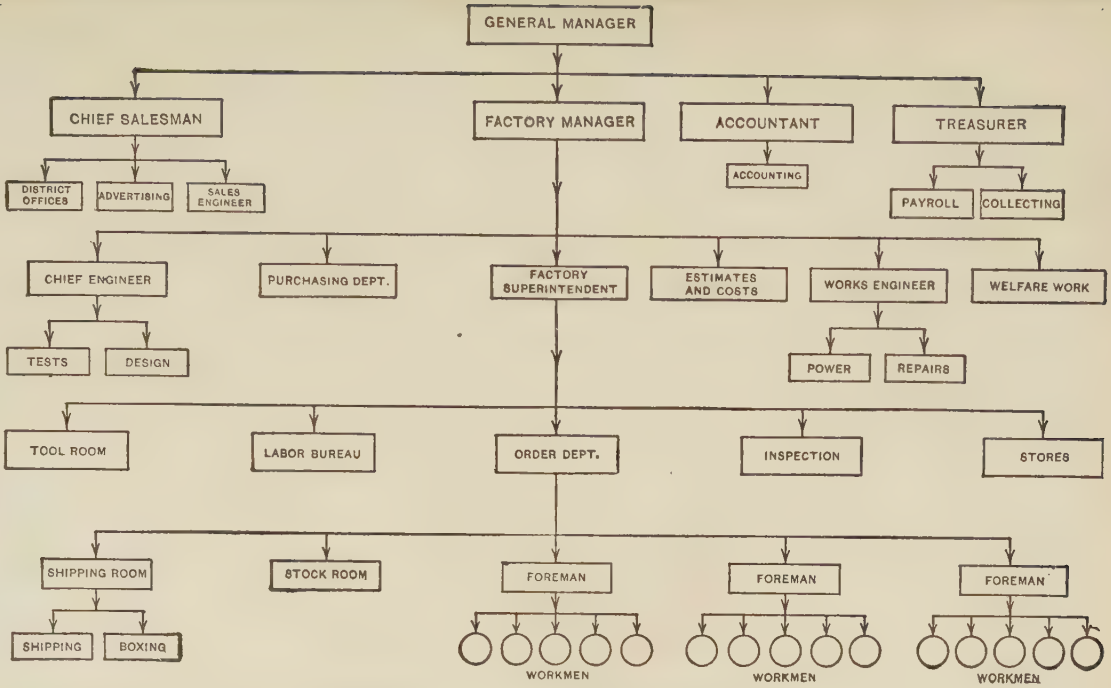


FIGURE 2. LINE AND STAFF ORGANIZATION

actual production problems involved in the accomplishment of the work devolve upon the factory manager. Under the factory manager again are grouped his own staff officers. One has charge of purchasing, one of tools and equipment, another has all engineering problems assigned to him, while others have the responsibility connected with costs or the problems of welfare. The factory superintendent has the actual work of production delegated to him by his superior officer, but he must take counsel and guidance from the others on the same functional level. A similar arrangement is seen in the lower part of the diagram in the organization under the factory superintendent. This method, while retaining the strong disciplinary features of line control, embodies the valuable quality of expert advice on the most important features of the work.

6. *Functional organization.*—Functional organization may be considered as an extreme application of staff control. Under this method the military or line features of control are practically obliterated and the work is divided strictly according to the functions to be performed. Such an organization is shown in Figure 3. Here the foremen, so called for lack of a better general term, are all specialists and do not perform the general duties of those in Figure 2. It is as tho the general foremen of Figure 2 had been taken apart and the like functions of each one collected together to form a new specialized type of foremen. Each workman receives expert advice or direction from

each foreman on the particular phase of the work concerning which the foreman is an expert. Thus one foreman may direct him to place the work in the machine, another may direct what tools he shall use and how they shall be used. Another may be charged with seeing that his machine is in good repair, and so

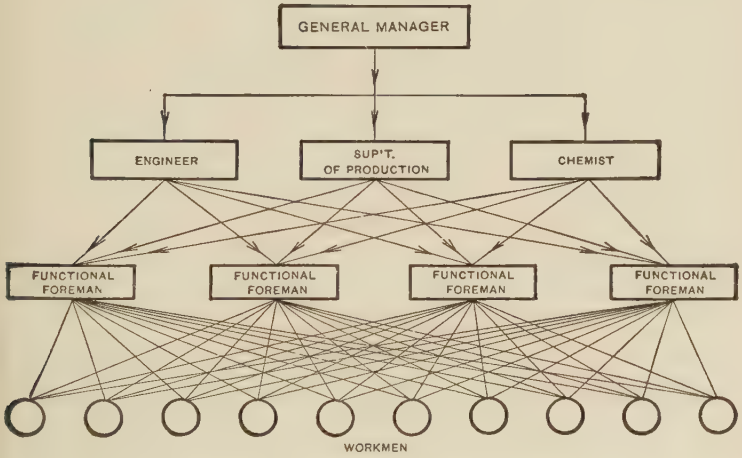


FIGURE 3. FUNCTIONAL ORGANIZATION

on, until the entire range of duties performed by the old general foreman in combination with the workman is carried out by this new combination of specialists. Obviously this method tends toward further division of labor and the separation of mental from manual processes in a very logical manner.

It will be clear that in such a form of organization the workman will be guided and advised on every detail of the work by men fully competent to give such

guidance and advice. On the other hand it will be equally clear that an organization of this kind affords most ample opportunity for disagreements as to authority, unless the duties of the several specialists are carefully coordinated. Functional management is markedly weak in disciplinary control.

7. *Line and functional control compared.*—The advantages and defects of line organization have already been noted. It will be remembered that line organization provides for perfect disciplinary control and leaves no ground for misunderstandings as to duties and rights. It is defective, however, in that it fails to provide for the division of labor and consequent specialization demanded by modern industry.

Pure functional organization, on the other hand, provides for the fullest application of division of labor in the most logical sense. From the standpoint of disciplinary control, however, it is exceedingly weak and unless carefully held together by strong coordinative methods, a purely functional organization tends to become chaotic.

For these reasons the purely military or purely functional form of organization is seldom seen, but the combination of the two in the form of line and staff organization so-called is the most common. This latter form is of course a compromise between the two extreme types, and if well laid out, embodies the important features of both systems. There is a decided tendency for organizations in general to de-

velop the functional ideas in combination with strong measures to insure coordination.

REVIEW

What are the characteristics of the so-called military organization in industry?

How are functions distributed under line and staff control?

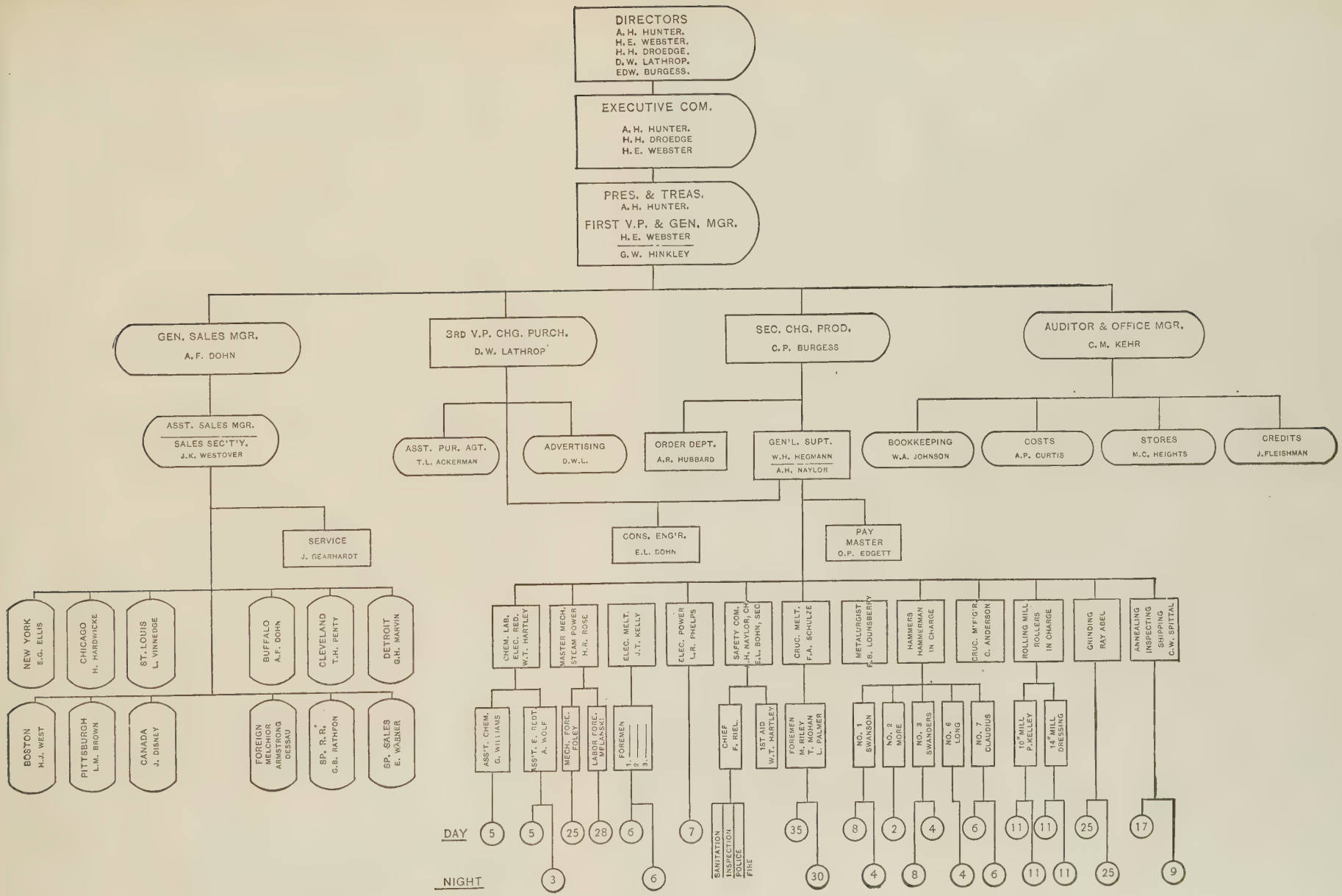
Describe the advantages and disadvantages of functional organization.

CHAPTER V

COORDINATIVE INFLUENCES

1. *Organization charts.*—It has been shown that as division of labor is extended it becomes increasingly necessary to provide ways and means of securing definiteness in the organization. Authority and responsibility are inseparable for good results, and as far as possible every man's duties should be clearly defined and his efforts coordinated with his fellow workers' toward the desired result. It is not good policy to leave uncertainty or doubt in any man's mind as to just what his status in the organization may be.

It has also been shown that since personal influence is not sufficient for this purpose where the number of men is large, other coordinative influences must be used. Organization charts have been found to be very helpful in this regard. Thus Figure 2 is a hypothetical organization chart for a fairly large manufacturing establishment. It shows clearly the relations between the several officers and men and leaves no doubt as to the relative duties and authority of each. This form of chart is therefore sometimes called a diagram of authority. In some cases the chart is supplemented by what may be called an or-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NO. 1 SWANSON
NO. 2 MORE
NO. 3 SWANDERS
NO. 6 LONG
NO. 7 CLAUDIUS
10" MILL P. KELLEY
14" MILL DRESSING
DAY
NIGHT
5
5
25
28
6
7
35
8
2
4
6
11
11
25
17
3
6
SANITATION
INSPECTION
POLICE
FIRE
30
4
8
4
6
11
11
25
9

FIGURE 4

ganization record. In such a record the duties and authority of each man are put into written form and bound into book form so as to leave no question as to rank and duties. Whether such elaboration is necessary or not, it is important that there be no misunderstanding in these matters. They should not be permitted to remain, as they too often do, a source of irritation and dispute which retards production. Figure 4 shows an actual administrative diagram which was made to clarify the administrative status of the officers of a medium-sized concern that had grown rapidly from a small beginning. The arrangement may not be quite so logical as the hypothetical diagram of Figure 2, as it necessarily conforms somewhat to existing circumstances in the plant. It makes perfectly clear, however, the status of all concerned and makes good use of both line and staff methods.

2. *Orders and returns.*—It was noted in Chapter IV, Section 21, that the several departments of a modern organization are held in permanent relation to one another by means of written communication rather than by personal contact, and that the commonly accepted name for all such documents is the "system." The variety of these documents is endless and their form and content must necessarily differ in different establishments. Little is to be gained, therefore, from detailed discussions of them. If the purpose of a blank form is clearly known, there is little difficulty in making such a form as will answer the purpose fully.

In general, forms are classifiable into two important groups, namely orders and returns, and this classification is a helpful one in considering problems of organization. Orders include all instructions and directions that are issued from the several officials and departments that are charged with conducting the work, purchasing material, shipping finished product, etc. Returns include all documents that record the results of operations, accounts of material used, labor paid for, etc. In brief, orders direct how work shall be done and returns record how it has been performed. For convenience and dispatch, orders and returns are usually made on printed forms to reduce the amount of information that must be filled in by hand. The production order shown in Figure 10, page 101, is a good example of its kind. It tells the foreman or workman just what is to be done and the particulars concerning the work, such as the numbers of the job, the time when needed, etc. The time cards illustrated in the Text on "Cost Finding" are excellent examples of returns. They state how long the workman has been performing the task and the labor cost of the same. The orders flow downward, so to speak, in the diagram (Figure 2) to the points where the work is being performed while the returns flow upward to the places where the records of performance are kept.

Written instructions and returns are essential in administration since they give definiteness to all communications, fix responsibility accurately and make a

permanent record of each transaction. Orders, in general, can serve but one purpose, namely to direct how work shall be done. Returns, however, have a somewhat broader usefulness. Primarily they record the immediate results of operations, but they may also be of great use in compiling statistical records and reports that will be invaluable, first in predicting future operations, and second in directing the general policy of the undertaking.

3. *Administrative diagrams.*—While the diagrams in Figures 1, 2, 3, and 4 give an accurate idea of the relative authority and responsibility of all officers and departments, they do not show clearly the character of the communications that should pass between different departments, or the most economical manner in which the business between departments can be conducted. It is essential that correct information should go to those for whom it is intended and to them only. It is undesirable and wasteful to inform officers and departments concerning matters that lie outside their jurisdiction. There may be officers in the organization who do not rate very highly so far as authority is concerned, but who may be very important personages in the actual operation of the shop routine.

It is often an excellent plan, therefore, to lay down an administrative diagram for the enterprise. Such a chart will show the paths by which orders and returns move from department to department. This aids in planning the most efficient means of communi-

cation, eliminating useless documents and "red tape," and insuring that only those who are entitled to confidential information will receive it. The paths which orders and returns are to follow between departments can be indicated by lines of different character and written directions may supplement the chart.

If such a chart is laid out with reference to the geographical relations of the several departments, it may serve also as a basis for a messenger service which will facilitate the transfer of documents from place to place. Many managers would be greatly benefitted by laying out authoritative and administrative diagrams, if for no other reason than to discover the overlapping and duplicating which so often exist. To lay out such diagrams also compels the manager to think clearly and logically regarding his organization, the functions to be performed and the personnel that is best fitted to perform these functions.

4. *Committees and their characteristics.*—It is axiomatic that where several men are working on different phases of the same problem their efforts will be more effective if they can compare experiences and progress. It is in fact imperative, where wide division of labor is used, to provide special means for accomplishing this end, and there is nothing comparable to a committee for this purpose. Industrial problems are usually complex, and, in general, no one man is competent to solve them. It is often necessary, therefore, to call together those representing

the several functions that were once exercised by one man and to decide the question under consideration after it has been viewed from all angles.

An illustration may make this point clearer. Suppose a case arises, as it often does, where it is imperative that the cost of a given article be reduced; and suppose further the cost department has presented to the factory manager a special cost report showing in detail the labor, material and expense that has been expended upon the article in question. It will be assumed, also, that the article is made in quantity and requires the use of special tools and fixtures. The questions involved, therefore, have to do with the theoretical design of the article, the design and use of tools, the number of articles to be made at one time and the efficiency of the shop processes employed. The men most naturally fitted to serve on a committee to discuss these points are the engineer in charge of design, the toolmaker and the shop foreman, with any other shopmen who are familiar with the processes of fabrication which are involved.

Each and every phase of this problem can be discussed by such a committee very intelligently. A change in the design may greatly simplify the tools needed; a suggestion from a shopman may greatly reduce the labor cost. Difficulties in fabrication may be removed by slight changes in form, and in countless ways the discussion will bring out ways and means of reducing the cost and of improving the product to a degree quite beyond the power of any one man.

No one can appreciate the possibilities of such a committee until he has had experience with one of the kind that has just been suggested. An open discussion around a table by all concerned will almost always bring all phases of the problem to light and suggest ways and means of meeting difficulties and facilitating results.

A committee possesses certain natural advantages which should be noted. It is impersonal and jury-like in its action, and its findings are based on the facts presented rather than on personal opinion. The members of a committee are in duty bound, in deference to the opinions of their colleagues, to lay aside personal animosities and to do their best to promote the desired result. A member of a committee is more likely to tell the exact facts at the committee board than he would over the telephone, and the findings of a committee are likely, therefore, to be more accurate than an opinion collected piecemeal from various individuals.

The committee system assists also in awakening an interest in the work in hand and helps to promote sociability and a better understanding not only among men on the same level of authority, but also among men on different levels if the committees are formed with that end in view.

While committees will bring out the true facts concerning a matter and indicate the best procedure, they cannot direct operations. They are, necessarily, of an advisory character and cannot in any way replace

a strong personality in executive matters. Good committees, however, can greatly assist a strong executive by bringing out clearly what should be done and in enlisting the help and sympathy of all concerned in the result. In general, committees should not be too large as they then become cumbersome. Six members are usually sufficient. If the committee is too small all sides of the question may not be presented. Committees may be of many kinds, but only such representative ones will be discussed as will show the scope and method of their action.

5. *Executive or manufacturing committee.*—An excellent example of the need of a committee is shown in that level of authority in Figure 2, which includes the sales manager, factory manager, accountant, and treasurer. These four men, with the general manager, represent the various functions of the executive power. No one of them can intelligently decide difficult questions of policy. But when the five men are assembled as an executive committee, each of the important functions is represented by an expert and the discussions of such a body are wise and sound.

The general manager would be the natural chairman of such a committee, and the matters that would usually come before it will pertain to the general policy of the factory. Thus the committee might logically decide the character and size of the articles to be manufactured. It might well approve all manufacturing orders for either stock orders or special product. It would naturally decide all extraordinary

expenditures and would consider all economic problems of the plant. In certain kinds of manufacturing the engineering problems are of such paramount importance that the engineer has a function as important as those of the chief salesman and the factory manager. In any form of organization his counsel is important and cannot be neglected.

6. *Equipment committee.*—The executive committee consists mostly of men on the same level of authority. The equipment committee would naturally consist of men drawn from different levels. Thus in Figure 2 this committee could very well consist of a representative of the superintendent's office, the toolmaker, and any other men from the shop who may be of service. The engineer or his representative may also be included in this committee with advantage. If the plant is large enough to employ an equipment manager or works engineer, he would be the natural chairman of this committee.

Such a committee would discuss all problems concerning new tools or improvements of existing equipment. When discussing ways and means of reducing the cost of manufacture of any particular line of goods, the engineer who is familiar with the line should always sit with the committee. An engineer, a good toolmaker and a good manufacturing foreman together can often work wonders in reducing costs which would be beyond the power of any one of them singly. A committee of this kind is also

very valuable in establishing standards and in advising the executive committee regarding standardized product.

7. *The shop conference.*—Just as there are many-sided problems for the executive side of industry, so there are many similar problems in actual production. Manufacturing is usually a very complex process except in strictly continuous industries, and even with the best of systems many predictions will go astray. Adjustments must be made and new plans laid out to hasten production so as to meet delivery dates. A committee composed of the shop foremen or similar men, with a representative from the order department and with the superintendent as chairman is most effective in solving production problems. Such a committee would naturally discuss all matters pertaining to the operation of the factory and the status of production orders, and the discussion would bring to light any portions of a given production order that were behind schedule and the reason why. The findings of such a committee may, in fact, constitute a progress report of all work in process and thus put into the hands of the superintendent first-hand information as to what should be done to hasten matters. Committees of this kind, composed of men who are actually in touch with the work, are of great value if they are properly conducted.

8. *Summary.*—The committee principle is of very wide application, not only in connection with the

actual work of the factory but also in connection with the personal side of the organization. A suggestion committee for soliciting and rewarding good suggestions from the workmen regarding the conduct of the factory has been found to be a valuable feature in some plants, as has also a complaint committee for settling differences between the men and the management. Committees on welfare work, so-called, are also quite common.

Whatever the function of the committee may be, it should be conducted on business-like principles. The meetings should be called at regular intervals; careful minutes of the proceedings should be kept, and attention given to its findings and recommendations. The organization of committees, however, like all other instruments of management, should be done with discretion and wisdom. The number and character of the committees that may be necessary will, naturally, depend on the size and character of the factory. The committee system has limitations that must be observed for efficient operation. A committee that will be highly useful in one place may be useless elsewhere, and in a small factory a committee may be the cause of an actual waste of time. The work of committees is closely connected with factory reports. As a discussion of such reports will be much more illuminating after a discussion of the work of certain departments, it is deferred to a later section.

REVIEW

Into what two general groups are the forms employed in a modern organization divided?

What is the function of an administrative diagram and what are its advantages?

Do you regard a committee system as advantageous in dealing with the problems that arise? If so, why? What are the functions of an executive committee? An equipment committee?

CHAPTER VI

PURCHASING

1. *General.*—The first step in the production of any article is to obtain the necessary materials. All industrial effort is concerned with the transporting of physical materials and their transformation into other forms that are more serviceable. Material in the natural state usually possesses potential value only. As labor is bestowed upon it, the material rises in value; in fact practically all industrial values are principally labor values. Thus a pound of iron ore in the side of a hill has potential value only and may be bought for a fraction of a cent. This same iron ore when smelted into cast iron may be worth a cent a pound; when manufactured into Bessemer steel it may sell for one and one-half cents per pound. If made into crucible steel it may be worth twenty-five cents or more per pound, and if made into watch springs it will be worth many dollars per pound. This is true of all manufactured products. Industrial values are, largely, accumulated labor values; the value of the material in the original or natural state being usually a small part of the market value.

In the great majority of industrial pursuits the production of marketable products is divided into

many stages, only a limited number being performed in any one plant. In a few cases such as cement works and salt works, the transformation of the natural product to the finished article of commerce is performed in a single plant, but even such plants, in general, require certain supplies and auxiliary material that must be obtained from other manufacturers and which may have involved the work of several factories. In the majority of cases most market products are the results of several distinct stages, and these stages may be separated widely, both geographically and by manufacturing characteristics. The material that is required by a large electrical manufacturing plant, for instance, is of tremendous variety and is gathered from many sources. Practically all, however, has had more or less labor expended upon it before it is received at the electrical works.

It appears, therefore, that the article which one manufacturer looks upon as finished product may appear to other manufacturers as raw material or supplies; and the extent to which any manufacturer controls the sources of such raw material or supplies may vary greatly. Probably no industry exists today that is not dependent in some measure upon other industries for some portion of its supplies, and the extent to which it will pay any given manufacturer to engage in making what would normally be considered supplies is a nice financial problem involving the basic principles of manufacturing. (See Chapter III, Section 3.)

Since material represents value just as much as does the cash in the safe, it would seem to be unnecessary to urge that proper supervision be exercised over all operations involved in its purchase and use. It is true that in many industries, where the material used is very cheap, extreme care may seem unnecessary and simple methods may suffice. Even here, however, purchasing is of extreme importance since in such cases the quantities are usually large. It is amazing to see the complacency with which some factory managers view material wastes in purchasing and fabrication which involve the loss of thousands of dollars, while at the same time exercising the greatest vigilance to avoid the loss of a cent in cash. Wastes of this kind go on day after day in some shops, but any effort to stop them by means of intelligent supervision would be met instantly with opposition on the ground of unnecessary expense or the plea that such supervision would hamper production. No well-regulated enterprise in which the materials used are an important financial factor can afford to be without a well-organized purchasing system and a good cost system that provides accurate records of all material from the time it is ordered until it is shipped as finished product.

2. *Importance of purchasing.*—It would seem unnecessary, therefore, to urge that purchasing, the first step in the process of production, should be conducted with foresight and care. Yet there are thousands of manufacturers who are doing their buying in an un-

systematic piecemeal fashion that must result in serious losses and delays. The custom of buying all kinds of supplies in small lots from local jobbers is only too common. The local jobber may be a good buyer or he may not. In effect this practice of depending upon the local jobber is to delegate an important financial matter that should be closely connected with the active life of the factory. Of course a small company cannot afford an elaborate purchasing department, but no concern is so small that it will not pay to have the purchasing supervised, careful records of all purchases maintained and an effort made to buy closely by securing competitive bids.

3. *The purchasing department.*—Whatever the size or character of the enterprise, the purchasing should be centralized. Where this power is delegated to several persons, or is left to any one on whom the responsibility may happen to fall, economical results cannot be obtained, and the first opportunity to secure low production costs is lost thru loose and extravagant methods. Loose methods also open the way for dishonesty. A case of this kind came under the writer's observation some years ago in which a certain yard foreman who had the authority to purchase lumber for the works built an addition to his house with lumber for which his employers had paid a good price. The temptation to do this sort of thing should be removed from all concerned. Organized, systematic methods of purchasing are imperative and the responsibility should be placed so that all transactions

will be checked just as accurately as the pay-roll or any other financial transaction.

In small concerns the purchasing may be done by an officer who has other duties as well. But following the law of division of labor, purchasing should become an independent function as soon as the quantity to be purchased will justify such segregation. In large companies the purchasing department may become highly organized, and with many subdivisions. In Figure 2 [1] the purchasing department is placed under the factory manager, which is not unusual in manufacturing organizations where the obtaining of materials for fabrication in the factory is the principal work of purchasing. It is obvious, however, that in other forms of industry the purchasing may be supervised to great advantage by the general manager or treasurer, as has been done in Figure 4.[2] Like all other departments of an organization, the purchasing department will naturally develop its own system of handling information and conducting its routine business. Such a system cannot be transplanted; it must be a growth.

4. *The purchasing agent.*—Perhaps no officer of an organization should be more carefully chosen than the purchasing agent. A good purchasing agent is always a most valuable man who can save the concern much money. It is obvious that a purchasing agent must be well trained in business methods and must have the commercial instincts that will make

[1] Page 33. [2] Page 41.

him a keen judge of values. He must also be a close student of market conditions. That he must have confidence in himself and a personality which enables him to deal with men effectively needs no special emphasis.

It should always be remembered that successful purchasing in an industrial establishment involves more than natural purchasing skill and a knowledge of markets. A successful purchasing agent should know intimately the processes and operations for which he is buying material, and he should be furnished, wherever it is possible, with carefully prepared specifications in regard to the material which he is to purchase. Such knowledge enables the purchasing agent not only to guard against mistakes but also to discriminate between the several kinds of material that may be offered, and that may seem superficially to be alike.

Of equal importance is a knowledge on the part of the purchasing agent of the article to be purchased. A man may be well qualified to purchase carpets but be wholly unfitted to purchase electric motors. And this knowledge of the article to be purchased may need to extend to a clear understanding of the processes by which it is produced, to enable the purchaser to judge whether or not a bidder is adequately equipped to fill a contract under consideration.

The technical knowledge required by a purchasing agent in many industries may therefore be very great, and an agent who possesses also the requisite

purchasing information and skill is an invaluable aid in securing low productive costs. For these reasons a man promoted from the shop or engineering department to be purchasing agent, all other things being equal, will make a better purchasing agent than one promoted from the clerical force. Shop men and engineers, however, are usually lacking in a knowledge of business forms and methods, and purchasing agents, therefore, are most usually recruited from the office force.

5. *Authority of the purchasing agent.*—In many industries it is very necessary that the authority of the purchasing agent should be carefully defined. Twyford in his book on purchasing quotes the regulations of a large corporation as follows: "The purchasing agent is charged with the purchase of all materials and supplies. A requisition signed by the head of a department shall be sufficient authority for the supply of materials which *in the opinion of the purchasing agent* are necessary for the execution in the ordinary course of the duties with which they are charged."

While such power may very well be given to the purchasing agent in some instances, it is entirely out of the question in others. The purchasing agent might very well refuse to order an abnormal supply of coal or lead pencils and he might with justice question any requisition that called for material of a quality that he did not approve. But in manufacturing which rests on a highly scientific basis, such as electri-

cal construction, the purchasing agent cannot constitute himself the judge of the quality of materials. This, in general, must be specified for him by the engineering department, and his duties then should be confined to obtaining the article in question at the lowest price, tho strictly in accord with the specifications. The same remarks apply to the matter of quantity. In many manufacturing plants the quantity of material required and the sequence in which it should arrive at the factory are manufacturing facts and not matters of personal opinion, tho here again a wise and tactful purchasing agent can save money by discreet inquiry and judicious buying.

Exceptionally large expenditures for materials should not be made without the sanction of the higher officials of the company. If a manufacturing committee has been formed (see Chapter V, Section 4) such matters would naturally come before it, as would also all large expenditures for machinery, equipment or other expenditures for the capital account. In the case of tools and equipment the recommendations of the tool committee are of great value.

While it may be necessary to limit the authority of the purchasing agent in the manner indicated, he must still remain the most important check against foolish and wasteful expenditures. If, while exercising a rigid check against such losses, he also realizes that his main function is to serve all departments and not to handicap them, he will prove to be indispensable to the organization. These relations may be made

somewhat clearer by considering the source of material requisitions and the general method pursued in filling them.

6. *Material requisitions.*—It is obvious that the character and quantity of the materials required depend directly upon the needs of the enterprise. They cannot, in general, be specified by the purchasing agent who is too often simply an expert buyer, tho, as previously noted, successful buying may require considerable technical knowledge. The material purchased for most enterprises is of two kinds, namely, material which is to go directly into product—direct material as it is often called—and supplies such as coal, waste, oil and the like that do not go directly into the product, yet are chargeable against production. The relative value of these two classes of material will depend upon the industry. In some general manufacturing industries the indirect material may be a small part of the purchases, and the authority for requisitioning it may be delegated to the storekeeper, the summarized accounts of the indirect material purchased serving as a check upon the quantities used. In other industries operating upon a large scale on cheap, direct material the indirect material may be a very important item and the authority to issue requisitions on the purchasing agent may be limited to more responsible officials.

In the case of a shop which principally does repair work, the material requisitions would most naturally originate with the foreman or the superintendent,

since in general only one or both of these would know what is needed. Where the factory is building new work involving the making of drawings and engineering requisitions, the material requisitions would most naturally originate in the engineering department. In many other cases the order department or planning department originates the specifications, basing them on the drawings and specifications or similar information. Requisitions made out in the engineering department are, however, likely to be more accurate than those made out in another department less familiar with the constructive features of the work.

In a factory manufacturing standardized articles in continuous operation the material requisitions may well originate in the stores department, since in this case this department is charged with keeping the factory supplied with material. All requisitions for indirect material or supplies would also naturally originate in this department.

There are many shops where all the three classes of work just mentioned are carried on. In such cases requisitions for the purchase of materials might properly originate from several sources. It is necessary, however, even in such factories to see that this authority is centralized and that only reliable and intelligent officials are given authority to make out requisitions for goods of any kind. Furthermore, no matter where the requisition may originate, it should pass thru the hands of the store-keeper so

that he may use whatever material he may have on hand or use up other material that may be substituted. Dead stores are, perhaps, the most unproductive form of invested capital; yet a casual examination of almost any large storehouse will usually show an amazing amount of dead material, much of which could be used up if proper care were exercised.

The particular form of the material requisition is not important, but whether issued by the foreman or by the order department, it should bear all the information needed to identify the material with the work or purpose for which it is intended. If the order is for a particular job, the requisition should give the job number, the time when the materials will be needed and all other particulars regarding the physical and chemical characteristics which it must possess. In large enterprises the requisitions are issued in multiple, one copy going directly to the purchasing agent. Copies may be sent to other officials, the practice varying with the particular system in use.

7. *Price, quality, and quantity.*—It will appear from the foregoing that price and quality may be closely connected and a low price may be of no advantage unless the quality is right. Low purchase price may indeed result in high manufacturing costs. Many large concerns now have well equipped test laboratories for determining the qualities of the materials used. Foundries now buy their iron by chemical specifications and careful managers specify the characteristics of such supplies as coal and oil. The

best purchasing results will be obtained when the commercial knowledge and skill of the purchasing agent is supported by the expert knowledge of the specialist who is well informed concerning the physical and chemical characteristics that are needed in the material to be purchased.

There is always a great temptation to buy material in large quantities. Lower prices can be obtained when goods are purchased in large quantities and a large stock on hand insures prompt service to the shop. Intelligent ordering, however, will take account of other factors. Material in stores is capital tied up and, obviously, there is no profit in ordering large quantities of an article unless the gain in price is greater than the interest on the investment during the time it lies in the storeroom. The quantity ordered should, therefore, have a reasonable relation to the prospective output of the plant. Careful inquiry should always be made before ordering a large quantity of any material—particularly special material—in order to be sure that there are no prospective changes in design that would render the material obsolete, a possibility which frequently presents itself in an industry that is developing rapidly.

8. *Time of delivery.*—While it is important that all material should arrive at the factory in ample time for fabrication, it will be clear from the preceding section that there is no profit in having it arrive too early. In the case of contracts that are to extend over a long period of time, therefore, the arrival of

material should be carefully scheduled. Clearly, it will not pay to buy large quantities of copper at the time a contract is secured when it may not be needed for a year. It is in such cases as this that a good planning department working with the purchasing agent can save much money by laying out schedules of delivery. In a similar way good purchasing will make long-time contracts with periodic deliveries for such material supplies as coal, oil, etc. On the other hand the purchasing agent is often justified in paying a high price if by so doing he can obtain a quick delivery which will facilitate the completion of a contract which is being delayed for want of goods.

The four factors just discussed, namely price, quality, quantity and time of delivery, are the most important features of purchasing. The verification of purchased goods is closely connected with these features and is discussed in a later section. Before taking up the verification of purchased material, however, it may be well to discuss the last step in actual purchasing, namely issuing the purchase order.

9. *Purchase orders.*—The problem of obtaining the material specified by the requisition belongs to the routine of purchasing which as has been noted is omitted from this book for lack of space. Certain requirements, however, must be included in this routine, if for no other reasons than the obtaining of accurate costs and the identification of the material with the work or purpose for which it is intended. The purchasing agent bases his purchase order on which

the goods are bought upon the material requisition.

A typical purchase order is shown on Figure 5. This order, besides giving the necessary information regarding the material needed, will bear the requisition number and, if necessary, the production order number of the job for which it is intended, and will, in addition, be given a serial purchase-order number as

BROWN MFG. CO.
BOSTON
PURCHASE ORDER

TO_____
ADDRESS_____
PLEASE SHIP THE MATERIAL DESCRIBED BELOW
PLACE OUR PURCHASE-ORDER NO. ON ALL INVOICES
SEND DUPLICATE INVOICES AND BILL OF LADING

PURCHASE-ORDER NO._____
PRODUCTION-ORDER NO._____
REQUISITION NO._____
DATE _____

SHIP ON OR BEFORE	DESCRIPTION	QUANTITY	PRICE

BROWN MFG. CO.
PER_____

FIGURE 5. PURCHASE ORDER

indicated in Figure 5. The purchase order will also bear a request to the merchant from whom the material is purchased to place the purchase-order number upon the invoice of the goods so that they may be identified upon arrival with the purchase for which they are intended. The purchase order will also bear full shipping instructions; sometimes a return receipt is attached which the merchant from whom

the goods are purchased may tear off, fill out and mail as an acceptance of the order. A copy of the purchase order is sent to the receiving department so that the goods may be identified upon arrival. The material ordered is thus fully identified with its purpose whether it be for fabrication, for supplies or for some specific piece of work.

It should be noted that if this purpose is to be attained, oral orders must always be carefully confirmed by the regular purchase order. The promiscuous ordering of material by telephone by those not authorized to do so should be strictly prohibited.

10. *Receiving and inspecting materials.*—Provision should always be made for a thoro inspection of all materials that are purchased. In small plants this may be accomplished by placing the receipt and inspection of purchased material in the hands of some one person specifically charged with these duties, but in larger plants a well-organized receiving department is essential. Sometimes this department is directly under the purchasing agent; occasionally in medium-sized plants shipping and receiving are combined. Ordinarily, a good arrangement is to make the receiving department a part of the stores department, tho in very large enterprises it may be better to organize an independent receiving department.

When an invoice of material has been inspected, a receiving memorandum vouching for the details of inspection is made out by the receiving clerk and checked by other officials as far as may seem neces-

sary. Sometimes a copy of the purchase order itself is used for checking up invoices. This practice, however, is not to be recommended since experience shows that greater accuracy is obtained where the invoice is checked up independently and then compared with the purchase order. In either case the receiving clerk also places upon the memorandum the purchase-order number and the production or shop-order number, if the material has been ordered for a particular job, or the stores-order number if it has been ordered for general stores. He may also fill in any freight, cartage or other transportation charges and state whether they have been paid or not. Copies of the receiving memorandum are sent to the storekeeper, the purchasing agent, the accountant and as many others as are interested in the transaction according to the system in use. The material having been thus checked and identified is taken to stores or directly to the production department as the case may be.

The actual inspection of purchased material may include visual examination as to the quality and quantity, or it may include chemical and mechanical tests to determine whether the materials are fully in accord with the purchase specifications. In the case of such articles as taps and dies, small machine screws and similar supplies, the question of interchangeability may be highly important and the inspection correspondingly searching. Accurate inspection is a source of great saving in such cases. An error in

production, because a tool or screw is not correct, may be very serious where large numbers of parts are to be produced. It is also advantageous to be able to identify material that may develop defects during fabrication in order that proper claims for reimbursement may be made. Inspection during manufacture is, however, discussed in the chapter on inspection.

11. *Purchase analysis.*—In some enterprises not only are the purchased materials of great variety, but they are used for many purposes, some of them going into stores first, some going directly to the factory and some passing to outside constructions or directly to a customer. Furthermore, the number of invoices may be so great as to become burdensome if carried directly to the general books. In small factories the invoices themselves may be filed and indexed and the items posted directly from the file to the cost ledger or the general books as may be desired. But in large and complex industries it is better to enter the details of invoices in a purchase-analysis book or purchase record as it is sometimes called.

A typical form for the page of such a book as might be used in a machine-manufacturing establishment is shown in Figure 6. Each page may be devoted to the record of one kind of material and will, in general, record the purchase-order number and perhaps the invoice number. It will record the date of the order, the name of the dealer and such descriptive details as may seem necessary. In addition, it will be provided with

columns for recording the distribution of the material. Thus in Figure 6 provision is made for keeping a record of all material going to the storeroom, to work in process, to commercial costs directly, and to suspense accounts; there is also provision for debiting unclassified accounts. A space is left for recording

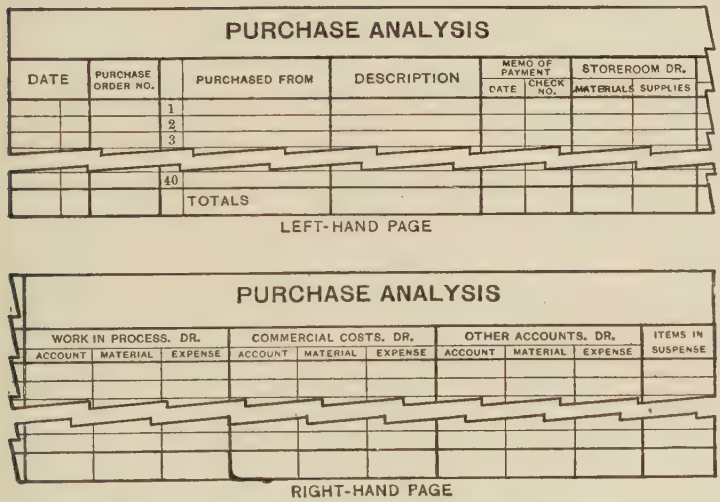

FIGURE 6. PURCHASE ANALYSIS

payments that may be made on any invoice that is recorded. The detail to which this analysis is carried will, obviously, depend upon the characteristics of the business, but it is clear that such a record is conducive to a clear understanding of just how all incoming material should be charged and distributed in the costs. This matter is, therefore, referred to again in the volume on "Cost Finding."

REVIEW

What is meant by the statement that industrial values are largely accumulated labor values?

In view of the great opportunity for loss thru inefficient purchasing of materials and supplies, what, in your judgment, is required of an efficient purchasing department in an industrial establishment?

Distinguish between direct and indirect material.

In ordering large quantities of material for the purpose of obtaining them at the lowest price, what consideration would tend to limit the amount purchased?

What steps should be taken to insure a thoro inspection of materials purchased?

CHAPTER VII

STORING MATERIAL

1. *Stores and stock.*—In a continuous industry of the ideal type the material would be used as soon as it was received, flowing thru the factory without pause and going directly to the consumer as soon as it was fabricated. Such conditions are almost impossible to attain, tho closely approached in some of the simpler continuous processes. In most industries the rate of sale varies with the kind of product and with the season; and if prompt deliveries are to be made, a stock of finished product must be carried on hand. On the other hand materials must be bought in large lots in order that good prices may be obtained and they must be bought in anticipation of production so that work can be started promptly. In shops that make product to special order only, these features are not of such great importance; but even in these cases provision must be made for storing material in advance of fabrication and for storing the manufactured product until it is shipped. Stored material in any form represents inactive capital. The advantages of prompt service in manufacturing are supposed to compensate for more than the loss of interest on the investment, but this aspect of stored material should

not be overlooked, as storerooms are only too frequently sources of unnecessary losses.

Raw or unworked material is properly known as stores and the space where it is kept is called a storeroom. The function of the storeroom is to act as a reservoir between the stream of incoming material and the production department, equalizing the variations in supply and demand. Finished product ready for the market is properly known as stock and the place where it is kept is called a stock room. The stock room acts as a reservoir between the production department and the selling department, equalizing the variation in the demand of the market and the rate of production of the factory. A careful distinction should be made, therefore, between the terms stock and stores, which are quite commonly used indiscriminately. In a small plant the stock room and the storeroom may be one room and under the same officer, but even in such a case there are two distinct functions to be performed, and as plants increase in size a separation of the two functions becomes imperative if for no other consideration than that of space.

In addition to the raw material that is to be transformed into marketable product every factory must carry in its stores a considerable amount of indirect material; that is material that does not enter directly into the product, but which is essential to its production. In works such as smelting furnaces and rolling mills, the amount of material carried in stores for

repairing the usual wear and tear of the plant may be very great. Other supplies, such as coal and iron, must often be bought in quantities and stored in order that the best market prices may be obtained. Stores, therefore, may not necessarily be under a roof and in bins, but the basic problems involved are the same regardless of the location of the material that is stored.

2. *Finished-parts storeroom.*—Material which is being fabricated is known as goods in process. In intermittent manufacturing it is often necessary to arrest the progress of manufacturing at certain stages for economic reasons. Thus it is often necessary to finish up a large number of parts of machines or other products, and store them away, drawing them out as they may be needed for final assembly into a completed product. Such a proceeding is often made necessary in order to obtain the advantages of manufacturing in quantity. Or again, certain parts that require a long time for production, as compared with other parts of the completed machine, may be made in advance in order to insure prompt deliveries of the finished product. A supply of such finished parts may also be carried to furnish repair parts for apparatus already sold. Stored parts of this kind are known as finished parts, and in some factories a special section of the storeroom is set aside for them and is known as a finished-parts storeroom. Such a storeroom acts as a reservoir to equalize the variation in the manufacturing processes of the factory.

In some factories where the parts manufactured

are small in size but great in number they are stored regularly between successive operations in order to permit thoro inspection as to both quality and quantity. Such storerooms, however, are usually a part of the inspection system, and these parts, strictly speaking, are not finished parts till all work on them is completed and they are released from the custody of the factory foreman and deposited with the storekeeper. A distinction is sometimes made between finished parts that have been made in the factory and similar parts that have been purchased from a dealer. Bolts, screws and similar parts that are often purchased from other makers and used directly in the product, are, strictly speaking, finished parts as much as those made in the factory. They are sometimes called purchased finished parts to distinguish them from manufactured finished parts. This distinction is not important, however, as long as the clerical transactions involved in handling the two classes of goods are conducted so as to secure accurate costs.

3. *Administration of stock and stores.*—The storeroom, therefore, may care for three classes of material, namely stores or raw material which is to be fabricated, hence called also direct material; supplies or indirect material; and finished parts of product ready to be assembled into completed product. In many cases all three classes of material are handled by one department. But in large enterprises it may be an economy to organize separate departments to handle each class. Thus in large reduction works

the ore which is to be reduced might be cared for by one stores system, while the supplies necessary for repairs might be handled by a separate and distinct stores system. It will be noted that in large enterprises of this kind the item of supplies may be very large and the issuing of such material should, in consequence, be carefully guarded.

In some enterprises which manufacture only a few kinds of product but a large number of each kind, practically all parts may be stored in a finished-parts storeroom and drawn thence as required for assembly. The finished-parts storeroom then becomes of greater importance and may be managed independently of the storeroom for raw material. This arrangement is often found in factories that produce machine tools.

Technically the stock room should carry only completed product, but in many cases it may also carry a large stock of finished parts in order to supply repair parts to customers. In such cases, however, the finished parts so stocked are treated as finished product, whereas their status in the storeroom is somewhat different so far, at least, as cost-finding methods are concerned. It will be clear, therefore, that the best methods of administering the storerooms and stock rooms will depend on the character and size of the enterprise. In general, as industrial plants increase in size, it becomes necessary to separate functions which, in a small enterprise, can be managed collectively.

4. *Storeroom functions*—It has been shown that

the principal functions of the storeroom are to anticipate the needs of the factory. It will be assumed in the following discussion that no distinction is made between finished parts and raw material so far as these functions are concerned, as the storeroom problems are common. In general the storeroom, in order to do this work effectively, must perform the following functions.

(1) Check all material that is received if the receiving department is integral with the storeroom. This function has been fully discussed already.
(2) Issue or approve all material requisitions on the purchasing department for the most economical amount of material, fixing also the most economical time of delivery of the same.
(3) Store all material in a safe and convenient manner.
(4) Maintain exact records of all receipt and issues of material and of all balances on hand.
(5) Issue all materials and supplies only on requisition and in the exact amount called for.

It will be noted that the work of the stores department is closely connected not only with the purchasing department and the shop activities, but also with the cost department. As will be seen later, it can be

of great assistance where a department for planning the routine of production is in operation.

5. *Ordering material for repairs or for continuous production.*—The origin of all material requisitions was discussed in Section 6 of the previous chapter, and it will be remembered it was shown there that no matter where the material requisitions originate, they should pass thru the hands of the storekeeper so as to insure that no material is left unused before ordering more. For this reason it is good practice to draw all material requisitions on the storeroom, the storekeeper alone placing material requisitions with the purchasing agent.

The ordering of material for special work to be done to order or for repair work is comparatively simple, since in such cases the quality and quantity are fixed, in general, by the peculiar characteristics of the work. If, however, the work is of great magnitude and is to extend over a considerable length of time, the rates or times of delivery of the materials should be carefully planned by either the engineering or planning department in order to prevent tying up money in material a long time in advance of the period when it will be needed.

In continuous industries the case is even simpler, as then the storeroom bins are simply hoppers that feed the factory and storekeeping becomes simply a problem of keeping in touch with the rates of production and of establishing maximum and minimum limits to the amounts carried in stores, so as to prevent

over-investment on one hand and failure of production on the other.

6. *Ordering material for intermittent manufacturing.*—The problem of anticipating the needs of a large factory that is engaged in manufacturing standardized products of several kinds and many sizes in an intermittent manner is a very difficult one since it involves a consideration of the amount of material that should be carried in all stages of fabrication from raw material to finished product. These relations may be made clearer by considering the problem of manufacturing a line of alternating current transformers.

The demand for the smaller sizes of transformers of, say, fifty kilowatts and less, would be very large, tho varying. To facilitate deliveries a considerable stock of all small sizes would be carried in the branch sales office. These small sizes, therefore, would be practically in continuous manufacture; at least they would be passed thru the shop in large lots, finished completely and put into stock. The manufacturer would be justified also in securing a very extensive and perhaps costly equipment of tools and fixtures for these small sizes, since they would be looked upon as a regular product. The problem of supplying material in this case would be very close to that of continuous production. All that would be necessary is to avoid over-buying on the one hand and to make sure on the other that production should not be held up for lack of material.

Transformers from 100 kilowatts to, say, 250 kilowatts would present an entirely different problem. In general the demand for a given class of product decreases as the size of the unit increases. The seasonable demand for large transformers would vary more than in the case of the smaller sizes and the branch offices would not carry them in stock. The total yearly demand, however, may be such that it would be good policy to build these sizes in large lots, care being exercised that the size of the lots and the time of production be chosen so as to keep the material and wage investment at a minimum. Greater care should be exercised, therefore, in purchasing material for these sizes.

The problem of transformers of, say, 500 kilowatts capacity may be still more difficult. Here the demand may be so small that it is out of the question to build them in large lots and put them in stock because the interest on the money invested would more than offset the saving made by producing in quantity. But it may take such a long time to manufacture one of these sizes that the salesman may be badly handicapped. It would be good manufacturing policy in such a case to make up some of the parts that require the longest time to fabricate. For instance the copper coils can be wound up, insulated and carried as finished parts, providing in this way also for repair parts. Any malleable iron that may be needed can be carried in stores, labor being expended, however, only on those parts that will greatly facilitate rapid

production when orders are received. The expenditure for special tools would be kept as low as possible.

In the case of still larger sizes it may not be good economy to carry finished parts of any kind. Only such material as would require time to obtain would be carried in store. It should be carefully noted whether any of the material so stored is of special kind or size, since such material, if left on hand for any reason, depreciates rapidly and is likely to involve a direct financial loss.

The largest sizes of transformers, particularly those for high voltages, would be made entirely to order, no material being carried for their construction and no special tools being provided. The production of these sizes would be a problem in extreme intermittent manufacturing and the question of material would be very simple, the time of ordering and receiving the material becoming the important matters.

While the relative sizes assumed in the foregoing are hypothetical they are entirely possible and the principles developed are universal. It will be noted that where the problem approaches either the extreme case of continuous or of intermittent manufacturing the question of materials becomes simple. It is the cases that fall between these extremes that are the most troublesome and for the best solution of which the storekeeper may require the aid and advice of the salesman, the engineer and the manufacturing superintendent.

7. Storeroom methods.—It would seem to be essential to good shop management to have a properly equipped and well-managed storeroom. Aside from guarding valuable material from loss, good storeroom methods are absolutely necessary for accurate costs. A good storeroom will have a place for everything and everything in its place. All stores will be guarded as carefully against theft or unauthorized use as the cashier guards the cash. The writer is well aware that such detail is often considered a waste of time and money, and while it is true that there are cases where the supplies are so few or so cheap that it will hardly pay to employ a storekeeper, it is also true that such cases are infrequent. It is a rare instance where a stores system will not pay good dividends.

The exact method of storing materials will, of course, vary with the industry and with the class of material, but in any case all material should be stored in a convenient and accessible manner, so that it can be drawn with the least possible difficulty and so that account can be taken of it with ease and dispatch. In the best systems each lot of material, or each bin or receptacle, is numbered or otherwise designated, so that material may be found or referred to by list. Where the plant is large and several branch storerooms are in use, this system must necessarily be comprehensive. Thus the designation 6 A 24 *h* might mean that certain material was stored in building No. 6, division A, section 24 and bin or rack *h*. The de-

tails of storeroom construction and arrangement are well worthy of the careful consideration of the factory manager.

All material ordered for an industrial enterprise may be classified as either standard material, special material or supplies. Standard material includes such material as is used constantly in the product while special material is ordered for special purposes and should, therefore, be carefully considered. Supplies of indirect material include all factory supplies such as coal, oil, waste, etc., that like standard material are in constant demand by the factory. The general way in which the demand for standard material and special material may vary has already been discussed. The demand for supplies will, in general, vary with the volume of business transacted. It has already been noted that the storeroom bins and racks may be likened to reservoirs for equalizing the supply and demand of materials. The amount in each bin or rack should, therefore, never fall below a certain minimum limit nor should it exceed a certain maximum limit, these limits being fixed by the conditions of manufacturing.

The simplest method of insuring that a proper amount of each kind of material shall be on hand, when limits have been set, is that of observation of limits. A printed form is attached to each bin or rack, and on this form the limits are recorded. As material is drawn, the storekeeper deducts the amount so drawn, thus keeping a continuous record of stores

on hand. When the lower limit is reached, a requisition is placed for enough new material to bring the contents of the bin or rack up to the maximum. By this means the wants of the factory are anticipated and at the same time capital is not unduly tied up in idle material.

An objection to this method for large plants is the fact that the information regarding the state of the stores is widely scattered, and unless a classified index of the bin tickets is maintained it is difficult for the head storekeeper to check quickly the amount of any commodity. In addition to this disadvantage, the entries of additions and withdrawals, made on the bin tickets by storeroom assistants, are in general more or less slovenly, and there is considerable liability of inaccurate entries, both by accident or design, with consequent errors in the material records and costs. For these reasons well-organized plants resort to more accurate methods.

8. *Stores ledger or continuous inventory.*—In more highly developed forms of stores systems all records are kept by the head storekeeper or his clerk, either on a card system or in a loose-leaf ledger. Such a ledger has columns ruled to suit the special needs of the stores department and is commonly called a stock ledger. The term stock, as has been noted, refers more properly to finished product. The name stores ledger is more accurate when referring to the record of raw material and will be used in this work, tho it does not conform to common usage. A typical page

from such a ledger is shown in Figure 7, opposite. The record of only one item is carried on each page and this record, it will be noticed, includes not only all receipts and issues of the material recorded, but also all orders for new material and a record of any material on hand that has been assigned to work in process of manufacture. When a requisition from the production department is filled from the stores, it is cancelled and sent to the head storekeeper, and no record is necessary at the bin or rack. These cancelled requisitions, in connection with the verified invoices of new goods, give the storekeeper complete information regarding the condition of the material for which he is responsible, and if his department is properly conducted the stores ledger is a continuous or "perpetual" inventory of all material on hand in the stores. It is obvious that if this inventory is to be accurate, the storerooms must be absolutely closed to all except the storekeeper and his assistants. No material may be delivered except on proper requisition, and any discrepancy between the stores ledger and the bins should be investigated and accounted for. For accurate results these conditions hold also with the bin-ticket system. Accuracy in accounting for material is essential to accurate cost finding. Provision is usually made on the stores-ledger sheets, as in Figure 7, for noting the price per pound or piece and the total valuation, both for the purpose of inventory and for the purpose of correctly fixing the value of all goods issued from the stores.

STORES LEDGER

MAXIMUM _____
MINIMUM _____
DRAWING NO. _____
MATERIAL SPECIFICATION NO. _____
FOR APPARATUS _____

BUILDING _____
DIVISION _____
SECTION _____
SHELF _____
BIN _____

PURCHASED FROM	ORDERED			ASSIGNED		BALANCE AVAILABLE	INVOICE							ISSUES					IN STORES	
	DATE	REQ. NO.	QUANTITY	ORDER NO.	QUANTITY	QUANTITY	DATE	INVOICE NO.	REQ. NO.	QUANTITY	TOTAL REC'D	PRICE	COST	DATE	PRODUCT ORDER	QUANTITY	TOTAL	COST	QUANTITY	VALUE

FIGURE 7. STORES LEDGER

The function of a stores ledger is, however, somewhat broader than simply to serve as a means of keeping track of material. If properly kept, it enables the manufacturer to carry the minimum amount of material and hence to keep down his investment to the lowest economical point. A well-kept stores ledger greatly facilitates the care of the material and is a great check on wastes and losses due to carelessness either in workmanship or in the handling of materials. Where the material handled is varied and valuable there is the same need for a stores ledger as there is for a cash book, tho, curiously enough, it is often difficult to convince hard-headed managers that this is a fact.

9. *Storing indirect and special material.*—Indirect material or supplies are treated, so far as stores are concerned, in the same way as direct material. If the plant is large, they may be kept in separate storerooms, but this system is exceptional. The method of withdrawing supplies from the stores and of charging up their cost is, of course, very different from the procedure in the case of direct material.

Special material is ordered for some particular piece of work and is not ordinarily used in the manufacture of other products. It should, therefore, be ordered with care, only enough being obtained to satisfy the particular need, as any special material not used may depreciate in value very rapidly if left in the storeroom. Sometimes special material is not put into the storeroom, but is sent directly to the

place in the factory where it is to be used, its value being charged to the proper account in the general books or sent to the cost ledger, depending on the system in use. If, however, the time of the arrival of special material does not coincide closely with the time at which it is needed, it should be stored in the regular manner. It is bad management to have material which is not wanted lying around the factory.

10. *Administering finished-parts storeroom.*—It will be clear that where standard machine parts, such as bolts and screws, are made in the factory instead of being purchased, they would naturally be delivered to the storeroom and treated, as far as storeroom methods are concerned, like those that have been obtained by purchase. Machine elements such as gears, pulleys, parts of valve gears or portions of electrical apparatus which are to be stored and redrawn for final assembly into completed machines, present a somewhat different problem.

If the business is a large one, as previously stated, a separate storeroom, known as a finished-parts storeroom, may be maintained, but usually the one storeroom cares for both raw material and finished parts. Whether or not a separate storeroom is provided for finished parts, a careful and systematic record should be made of them, preferably on the continuous inventory plan. Figure 8 shows a typical finished-parts-ledger sheet similar to the stores-ledger sheet shown in Figure 7. The cost of the finished parts may or may not be entered on this sheet, since this

FINISHED-PARTS LEDGER

NAME_____
DRAW. NO._____
PAT. NO._____
MATERIAL_____
MAXIMUM NO._____
MINIMUM NO._____

FOR APPARATUS _____

BUILDING_____
DIVISION_____
SECTION_____
SHELF_____
BIN_____

ORDERED			RECEIVED			ISSUED				RESERVED		IN STOCK		UNIT COST	
ORDER NO.	DATE	NO. PCS.	ORDER NO.	DATE	NO. PCS.	ORDER NO.	DATE	TO SHOP	TO SALES	FOR ORDER NO.	NO. PCS.	DATE	NO. PCS.		

FIGURE 8. FINISHED-PARTS LEDGER

cost will always be available on the cost-ledger sheets that are illustrated and explained in the volume on "Cost Finding."

11. *Finished-stock record.*—Just as it is necessary to have accurate records of raw materials and finished parts, so it is necessary to have accurate records of

STOCK LEDGER

MAXIMUM _____ BUILDING _____
MINIMUM _____ SECTION _____
ARTICLE _____ SHELF _____
CLASS OR NO. _____ BIN _____

DATE		PRODUCTION			SHIPMENTS			BALANCE		
		QUANTITY	RATE	AMOUNT	QUANTITY	RATE	AMOUNT	QUANTITY	RATE	AMOUNT

FIGURE 9. FINISHED STOCK LEDGER

all stock. Such records not only guide the manager in placing production orders, but if properly studied, they will prevent the accumulation of obsolete stock. Records of this kind are usually kept on loose-leaf ledgers such as are illustrated in Figure 9, above.

A leaf devoted to each item of stock shows all receipts from the factory, all shipments and the balances on hand. The dates of all receipts and shipments are also recorded. This is important for two reasons;

first to show the rate of shipment so as to gauge the desired rate of production; and second to serve as an aid in judging depreciation values when inventory is taken. This last is highly important in a business which is developing rapidly. Thus a few years ago electrical apparatus held in stock became obsolete in a short time because of progress in the art. As this obsolescence occurs in the case of most manufactured goods, the stock record can be of great value in guarding against such loss.

The stock record gives the location of the apparatus which it records, the maximum and the minimum amounts to be carried, and also a column for its evaluation. The stores ledger, the active accounts in the cost ledger, which is described in the volume on "Cost Finding," and the stock ledger, which has been discussed, constitute a continuous inventory, and from them there can be obtained at any time the value of all material grouped in the three important stages of fabrication, namely, as raw material, as material in process and as finished product.

12. *Visual or physical inventories.*—It is still customary for many managers to take an inventory only once a year. Modern accounting methods demand, however, that an accurate record be kept of all changes in the value of a plant and of the material in all stages. It is quite easy to keep a fairly accurate record of all changes in the plant and the equipment, but without good stock-ledger and stores-ledger accounts not

even an approximation can be made as to changes in material values. With such ledger accounts and a cost ledger which records the changes in value of the material in progress, a complete continuous inventory can be maintained of all material whether as raw stores, in process or as finished product.

It is a good policy, of course, to make occasionally an actual visual or physical inventory of the entire plant, in order to verify these running inventories. A good storekeeper will constantly check up material on hand to see that no wastes are occurring from theft, carelessness or error, and to make sure that his stores ledger is a true inventory of the goods for which he is responsible. Where good storeroom methods are maintained in connection with a stores ledger, the checking up of the material on hand may be made a continuous performance, and where this is done systematically, the stores ledger can be made a very accurate record. This constant checking of bins and racks is useful also in that it brings to light periodically all dead stores, which are so common in most storerooms and which not only represent idle capital, but occupy valuable space in the storeroom or factory. A complete yearly visual inventory becomes, in such a case, simply a check on the accuracy of the stores ledger and stock ledger.

13. *Issuing and evaluating material.*—The problem of issuing and evaluating material is so closely connected with the problems of cost finding that it is

discussed in connection with that subject and reference is made, therefore, to the volume on "Cost Finding" for such discussion.

REVIEW

Distinguish between stocks and stores. Under which classification would you put finished parts?

What specific rules would you lay down for the benefit of the man in charge of the storeroom in order to insure a proper balance between supply and demand?

What is the big problem which the storekeeper must solve in ordering material for a factory which is producing certain articles intermittently?

What system of inventory would you demand in keeping track of stores on hand in order to avoid a loss of interest on money tied up in materials?

CHAPTER VIII

PLANNING AND PRODUCTION DEPARTMENTS

1. *Planning in general.*—The preliminary planning of industrial operations flows naturally from the separation of mental labor from manual labor. Planning in advance is one of the most common activities of all men in all lines of work. In all industrial organizations there is an immense amount of planning done, tho it is not always recognized and named as such. The economic gain from planning hardly needs discussion, for it follows, as has been stated, directly from division of labor. The idea, however, has come into great prominence of late in connection with certain features of modern organization that will be discussed.

It should be carefully noted that the planning of any operation can be done either by rule of thumb or on the basis of statistical records. A highly experienced man can easily plan a sequence of operations that will be effective, but the certainty with which it can be carried out will depend on the accuracy of his memory and experience unless he possesses recorded data on which to rest his conclusions. If there are several methods of doing the same thing, he will not, in general, be competent to select the best method

unless he or some other person has tried all of them and has recorded the results of experience. This is even more marked in the matter of predicting the time required to do a piece of work, since time is such an elusive quantity. When, however, accurate recorded data are at hand, work can be planned with some assurance that it will be performed as planned.

2. *Growth of the planning idea.*—Originally, of course, all productive labor was performed in the shop itself, the planning going hand in hand with actual production. This method can still be seen in many small shops, particularly where repair work is done. Now planning involves four distinct processes, namely:

(1) Planning what work shall be done
(2) Planning how the work shall be done
(3) Planning where the work shall be done
(4) Planning when the work shall be done.

3. *Planning the construction features.*—As shops grew in size it was perfectly natural, following the law of separation of mental and manual labor, for the executive to take upon himself the problem of planning what work should be done, particularly as he was the only one in touch with the markets and was responsible for securing work for the shop. This function still remains in the hands of the executive heads.

In manufacturing, the several steps listed in the preceding section correspond first to deciding what

product shall be made, second to designing the product, third to planning the sequence of processes and the particular equipment that is to be used in constructing the product, and fourth to planning the entire sequence of operations, including designing, with reference to time, so as to meet a specified date of delivery. With the growth of the scientific side of industry it became more and more necessary to study carefully in advance the construction of the product. As machines became more complex, furthermore, it became increasingly necessary to plan them in advance of construction simply to insure workability. The engineering department thus naturally came into existence as a planning department and at present it is the finest example of a planning department. It is true, of course, that much of the work of the engineering department is still based on general knowledge; but the progress that has been made by engineers is remarkable and indicates what may be done in predicting manufacturing operations when the amount of data bearing on industrial operations becomes comparable with that which underlies engineering calculations.

4. *Planning under old methods.*—The selection of the proper sequence of operations and of the equipment that should be used for any piece of work has been left, until quite recently, to the discretion of the foreman and the several workmen. The problem of getting the product out on specified time was also left to the several foremen, the superintendent trust-

ing to their natural cooperation to secure the desired results. These methods are still pursued in many establishments but there is a steady growth away from them and towards others that will be described.

Under these older methods the superintendent gave each job, large or small, a number, or other distinguishing mark, sent each foreman an order directing him to do his particular share of the work and trusted, as has been stated, that the foremen among themselves would do the work in the most economical manner and get it done by the required date of shipment. As plants increased in size and as machines became more complex, foremen found it increasingly difficult to perform these tasks relying on memory and oral instructions, tho the performance of some of these old-time foremen in this regard was little short of marvelous.

In the meantime other problems of production, as for instance the need of more detailed costs, has necessitated the issuing of production orders (see Figure 10) in greater detail so that a job consisting of many parts would not be built on one order but on as many as the need of detailed costs might require. These detailed production orders made possible the scheduling of the several parts of the product in point of time, the sequence of operations being still left to the judgment of the foreman and workmen. This scheduling as to time was in the beginning by departments only, and when extended to machines and processes was, and still is in most cases, an approxima-

tion only. In order to insure performance and correct necessary errors in the schedule, means for tracing the work thru the shop grew up, and while these efforts were largely empirical they were a great improvement over the old personal methods.

5. *Production departments.*—In this manner there have grown up in many factories what are commonly known as production departments. The name is a misnomer, however, as the production department, properly speaking, includes all men and departments that have to do with actual production as distinguished from sales and finance. A typical so-called production department will be concerned with issuing production orders, scheduling the work in point of time, so far as possible insuring correct sequence of work and the meeting of time limits by tracing the progress of the work thru the shop. Lastly, it will collect such records of performances, time and labor costs as are available. Many such production departments so-called are to be found today. It should be noted that the planning department, or production department, as it is sometimes called, should be under the superintendent of production. The policy, sometimes adopted, of making the production manager independent of the superintendent of production and thus also making him a thorn in his side, is not logical and leads only to bickering and duplication of effort.

6. *Stock-tracing ledger.*—The stock-tracing ledger grew out of efforts to solve these problems of scheduling and dispatching material thru the factory. Such

a ledger is usually of the loose-leaf type or else it is a card system; a single leaf or card being used to record the movements of one order or lot of material from the time it leaves the storeroom until it is delivered as finished product. It has been applied very successfully to the production of finished parts. This record is in reality a continuous progress report of the particular lot of material, the movements of which it records as it passes thru the factory. In simple systems these ledger sheets sometimes record the cost of the material as well as the labor accruing on it, thus combining the function of a cost ledger with those of a stock-tracing ledger. In general, however, it will undoubtedly be better to keep these two functions separate, using a cost ledger only for financial summaries of cost.

Stock tracing, so called, grew out of a logical need of knowing the progress of all jobs and of insuring that required deliveries would be met. From stock tracing have grown much more advanced systems that will now be discussed.

7. *Functional foremanship.*—The most noteworthy effort to plan production in advance is that outlined by the late Mr. Frederick W. Taylor in a classical paper entitled "Shop Management" presented before the American Society of Mechanical Engineers.[1] In this paper Mr. Taylor describes certain methods of production which he had put into effect in the Bethlehem Steel Company plant and elsewhere. It should

[1] See Volume 24 of the Transactions.

be noted, however, that while the organization which Mr. Taylor describes is applicable particularly to iron-working plants, the principles which he employed are universally applicable and this remarkable paper was immediately recognized as an epoch-making document. Every industrial manager should read it.

Under the Taylor plan the work formerly performed by the foreman and his workmen collectively is redistributed on the basis of function. A careful study was made to discover just what these functions are, and a functional foreman, or functional boss as Taylor called him, is appointed to perform each function. The planning functions were carefully separated from the executive functions and all planning was removed from the actual workers and concentrated in the planning department which was to plan for the constructive side of the work in the same manner as the engineering department plans for the designing side of the industry. It will be specially noted that the only principle embodied in this change is the separation of the mental labor of production from the manual labor (see Chapter II, Section 4) and the subdivision of each into several parts, each performed by one man. The plan is, therefore, simply an extension of principles long in use in other parts of the organization to the work of the foreman and the men under him. But this plan of organization affects the status of the worker so deeply as to raise other considerations which will be discussed later and which have caused the worker, in general, to op-

pose stubbornly the introduction of Taylor's methods. In his work at Bethlehem Taylor employed the following functional foremen:

In the Planning Department

(1) The Order-of-Work or Route Clerk
(2) The Instruction-Card Clerk
(3) The Time and Cost Clerk

In the Shop

(4) The Gang Boss
(5) The Speed Boss
(6) The Inspector
(7) The Repair Boss
(8) The Shop Disciplinarian.

A brief discussion of the functions of the officers of the planning department may make Mr. Taylor's philosophy clearer. A discussion of the work of the shop bosses will be deferred to a succeeding section.

8. *The order-of-work or route clerk.*—A route sheet or schedule of operations showing the complete path that the piece is to follow thru the several shops and the machines or men who are to operate upon it is prepared by the order-of-work or route clerk. This schedule is final and cannot be changed by shop officials.

From this route sheet the route clerk prepares the work orders or production orders (Figure 10) for each man or machine that is to operate on the piece in question. This work order will give full particulars

as to the material to be used, the general character of the work to be done, and instructions as to where the piece is to be sent after the operation is completed. It will also give the order number of the job and any other information or references that are needed to complete the information concerning the operation. In some large plants where the Taylor system has

DEPARTMENT	MACHINE NO.	ORDER NO.	WORK NO.
B	276	02467	31424
DRAWING NO.	PART NO.	INST. CARD NO.	BONUS CHART NO.
A 4168	C	478	3

DATE OF ISSUE			DATE WHEN WANTED		
MO.	DAY	YEAR	MO.	DAY	YEAR
12	2	18	12	6	18

MOVE TO R NO. 31427

NO. PIECES	NAME	OPERATION
4	CYLINDERS	BO

FIGURE 10. PRODUCTION OR WORK CARD

been used, both a route clerk and an order-of-work clerk have been employed, the first laying out the route and the second looking after its enforcement. Obviously, however, this arrangement is simply a subdivision of labor.

9. *The instruction-card clerk.*—The instruction card, Figure 11, bears the same relation to the plan-

ning department that the engineering drawing or specification bears to the drafting room. It gives a concise description of all drawings, jigs, fixtures and other auxiliary apparatus that may be needed. In its most highly developed form it will give in detail the cutting tool that is to be used, the number and depth of the cuts that are to be made, and the feeds and speeds that are to be employed. It may also fix the time in which the several operations are to be made, as indicated in Figure 11, and give information concerning piece rates and bonuses that are offered if the operations are performed as called for on the card. Such an instruction card leaves nothing to discretion or imagination but absolutely plans every step in advance.

10. *The time and cost clerk.*—It will be clear that the instruction-card clerk cannot make up an accurate instruction card unless he has accurate data on which to rest his time estimates. A later section will describe how certain industrial data are collected. Many of these data come naturally thru the cost system and the cost clerk will therefore be able to inform the instruction-card man regarding records of performance, wages, bonuses, etc. This particular clerk, it will be noted, had already made a place for himself in factory organization long before Taylor's work.

11. *Summary.*—The brief discussion of the idea of planning production processes that has been given in the preceding section should be carefully noted, not

STANDARD MFG. CO. NO. 275

INSTRUCTION CARD

ORDER NO.	DRAWING NO.	PART NO.	NO. OF PIECES	MATERIAL	MO.	DAY	YEAR
0456	241	3B	30	CI	7	24	1916

WORKMAN'S NAME	MACHINE	SPEED BOSS
Wm Brown	Lathe 65	Thomas Jones

	INSTRUCTIONS	TOOL	CUT	FEED	SPEED	PIECE TIME		LOT TIME	
1	Preparation							10	00
2	Chucking and centering							15	00
3	Rough face	F4	.15"	.06"	P4	8	00		
4	Change feed and speed						06		
5	Rough Bore, 2 Cuts	B3	.09	.08	G6	20	00		
6	Finish Bore	B4	.02	.10	G5	8	00		
7	Change Feed and Speed						06		
8	Finish Face	F6	.02	.15	M2	6	00		
9	Stop Machine and								
10	Take out Work						25		
11	Clean Machine and								
12	change Work Order							2	00
13									
14	Add 10% to Piece Time						43		
16									
16									
17									
18									
	TOTALS FOR ONE PIECE					42	80	27	00

TOTAL TIME FOR 30 PIECES = 42.8 × 30 + 27 = 155.40

TOTAL TIME ACTUALLY TAKEN 150.00

WHEN MACHINE CANNOT BE RUN AS SPECIFIED REPORT AT ONCE TO

R. S. Thomas

SIGNATURE OF SPEED BOSS

Thomas Jones

FIGURE 11. INSTRUCTION CARD

so much for the particular information given therein, as for the reason that it indicates the trend of modern organization. The methods are excellent illustrations of division of mental and manual labor, and of the application of coordinative influences thru the route sheet, instruction card and other shop methods which will be discussed in later sections. It will be clear that prediction of effort such as has been outlined above cannot be made unless accurate data on all shop appliances, performances of workers and an accurate inventory of needed material are available. The next chapter deals, therefore, with these correlated matters.

REVIEW

Show the possibilities of waste under the old system.

What are the four distinct processes in planning the production of any article?

What is the principle upon which Taylor worked out his "functional foremanship" idea?

Explain the relation that the instruction-card clerk bears to the other functional foremen under Taylor's plan.

CHAPTER IX

INSURING RESULTS—SECURING INDUSTRIAL DATA

1. *The gang boss and the speed boss.*—Planning a performance does not necessarily insure that the work will be done as planned. And in such refined planning as has been outlined in the preceding chapter, special care must be taken to see that the performance is carried out as planned, since the margin allowed in these time estimates is usually small.

The gang boss relieves the workman of all preparations for the operation such as getting the work from one machine to another in advance of the time when it is needed, securing all drawings, instructions, special tools, etc. If the work is heavy, he also sees that it is put into the machine properly and provides the necessary handling devices. He is responsible, therefore, for seeing that the work arrives at the machine or process on schedule time.

The speed boss oversees the actual production, making sure that the right tools or other appliances are used and that the operation is carried out in accordance with the instruction card. He is also an instructor, teaching the men the best methods and assisting them to do the work as outlined.

2. *The inspector, the repair boss and the disciplin-*

arian.—The inspector is responsible for the accuracy of all work both as to workmanship and finish. This official was also already well established before Mr. Taylor's time. The inspector's duties, or rather the problems of inspection, are more fully discussed in a later section.

The repair boss has charge of all machines, belts, etc., and is held responsible for seeing that all equipment is in first-class order and repair. He performs a collective function that formerly was carried on by each worker so far as his own equipment was concerned.

The shop disciplinarian represents the disciplinary function of the old foreman. He is expected to look after the general discipline and good order of the shop, act as an arbitrator of disputes and assist in adjusting wages.

It will be noted, therefore, that Mr. Taylor's plan virtually amounts to replacing all line organization below and including the shop foreman with full staff organization. It will be clear also that while the plan is absolutely sound in theory there are practical limitations to its application, and the possibilities of applying it successfully will depend on the size of the plant, the character of the processes and the amount of statistical data that is available for the purpose of making predictions of performance. There are certain other human considerations that affect the problem which are more fully discussed later in this volume.

3. *Order-of-work-methods.*—In Mr. Taylor's plan the old empirical planning of the foreman in respect to the order in which the operations are to be performed is replaced by a systematic plan, and the oral orders of the foreman are replaced by written orders. The most usual method of accomplishing this result is as follows: Near each workman or machine is placed an order box containing, say, four compartments. In the upper compartment are placed the instruction card, drawings etc. for the particular job in process in this machine. The next lower compartment contains similar information for the next job scheduled for the machine, for which the gang boss is making, or will have made, full preparation in the way of tools and other necessary appliances. The third compartment will hold the information concerning jobs, the sequence of which has not as yet been determined or is determined tentatively only by the route clerk. This third compartment may also be used for holding the information concerning jobs on which work has been temporarily suspended. The information here collected will be of no particular interest to the workman, but it is useful in showing the route clerk and schedule clerk just how much work is ahead of each machine, and is of service therefore in determining the schedule of new jobs that are to follow.

In the office of the planning department there will be a route rack or schedule board made up of groups of pockets similar to those just described, each group

of pockets corresponding to one of those at a machine, bearing the same number and containing duplicate cards and other information of those at the machine. When any change is made in the information at a machine, a similar change is made in the corresponding boxes on the route rack so that the route rack, or planning board as it is sometimes called, always shows the exact status of the work at every machine and of every workman. By means of this mechanism the route clerk who is fully informed concerning the dates of delivery, or of changes in them, can fully control the sequence of operation and make estimates of the time required to complete a given piece of work or of the time required to put thru a new job. In some cases three or four sets of hooks are used instead of boxes, and in some applications of the principle the planning board has assumed rather complex form. The general principles in most common use, however, are those outlined above. Figure 12 shows a planning board in use in the Eastman Kodak factory. It will be noted that the work is assigned to specific machines or operations and that the workmen are specified by name.

4. *Data for the instruction card.*—An examination of Figure 11 will make it clear that before an instruction card such as is there shown can be prepared, certain data must be at hand. Some of these data are to be found in most well-ordered factories, while others require special effort and investigations that are not in common use. Thus full engineering information and

STAYER Nº1
STAYER Nº4
STAYER Nº5
STAYER Nº6
CLOSING Nº2
CLOSING Nº3
CLOSING Nº4
STRIPPER Nº5
STRIPPER Nº6
STRIPPER Nº7
STRIPPER Nº8
STRIPPER Nº12
FLANGE Nº1
SHED Nº1
TABLE Nº12
GUMMER Nº5
GUMMER Nº7
TABLE Nº2
TABLE Nº3
TABLE Nº4
TABLE Nº6
TABLE Nº7
GUMMER Nº8
TABLE Nº10
CLOSING
S.E.S. Nº1
S.E.S. Nº2
S.E.S. Nº3
S.E.S. Nº4
S.E.S. Nº5
STRIPPER Nº21
CLOSING
GLUER Nº1
GLUER Nº2
GLUER Nº3
GLUER Nº4
GLUER Nº5
CLOSING Nº2
CLOSING Nº3
CLOSING Nº4
CLOSING Nº5

FIGURE 12

working drawings are necessary, but these are already a standard product of any good engineering department. Complete information concerning special tools and fixtures is to be had wherever a good tool room exists. A good cost system, which every up-to-date shop should possess, will furnish much accurate information as to records of performance on work that has been done before, and good storeroom methods will furnish accurate information concerning raw material and finished stock. The planning board will show the exact progress of all work in process.

There still remains the need of complete tabulated information concerning the cutting power and the feeds and speeds of all machines and, what is more difficult to obtain, full information as to the best forms of cutting tools, and the best combination of feeds and speeds or similar industrial data if the factory is not an iron-working plant, but engaged in some other line of work. This particular feature of these new methods should be carefully noted, for it promises to extend modern methods to a point undreamed of a few years ago.

5. *Data on characteristics of machines and processes.*—It is not a difficult matter to tabulate the characteristics of machines and processes in such a manner that an instruction-card man can select the combination desired, provided, of course, he has basic information that will enable him thus to select a combination of feeds and speeds. This information is not as yet available in most shops and must, in general, be col-

lected for all machines and industrial processes. Such information bears the same relation to the prediction of industrial processes as basic engineering data bear to the design of machinery. A beginning, only, has been made on this problem, and the amount of such industrial data that we possess is exceedingly meager. An interesting phase of this matter is the increasing demand on the part of those interested in these new methods for standardized tools and processes. At present a machine of nominal size as made by any given manufacturer differs greatly in its characteristics from that made by his competitors. Much of this variation is obviously unnecessary. Clearly there must be combinations of characteristics that are the best in any machine of given nominal size for given purposes. These new methods, therefore, will undoubtedly tend toward standardized product.

6. *Industrial data, cutting of metals.*—As an illustration of the complexity of industrial processes it may be of interest to note the efforts of Mr. Taylor to secure data on the art of cutting metals by machine tools. It would be most natural to suppose that experienced workmen would know more than any one else regarding the best shapes of cutting tools and the most efficient combination of feeds and speeds. It should be remembered, however, that all mechanics receive their training from their forerunners and that it is based on inherited practices that are never questioned by them. All handicraft trades and callings are filled with practices that have been transmitted

from journeyman to apprentice with superstitious exactness and often with no thought that a better way can be found.

Mr. Taylor found after long and careful study that there are twelve principal variables involved in cutting metals. Now the number of combinations that can be made with a given number of variables is the continued product of the number. Thus with four variables the number of combinations is $4 \times 3 \times 2 \times 1 = 24$. Obviously, no man can say that he knows the best way in which an operation can be performed until he has evaluated all the combinations in some way, and in the case of twelve variables this proved to be something of a task. In some instances the best solution is found by empirical methods after centuries of cut-and-try efforts. The common ax and the scythe are excellent examples of perfect tools that have been developed in this manner. Such processes of development take a long time, however, and it has been demonstrated that mathematical analysis is often a great aid in solving such problems.

A full discussion of Mr. Taylor's works is beyond the scope of this volume, but the reader is referred to the original paper in Volume 28 of the "Transactions of the American Society of Mechanical Engineers" as a document well worth reading. Mr. Taylor and his assistants reduced his experimental data to mathematical expressions. Even these proved to be cumbersome, complex and unusable in the hands of the ordinary workman. Mr. Carl Barth, however, suc-

ceeded in making them usable by means of very ingenious slide-rules by which the best combination of feeds and speeds could be obtained by the ordinary worker.

These experiments are quoted not because of their intrinsic value so much as for the lesson they teach. Mr. Taylor's work did not cover all kinds of metals, and new steels and materials have made some of his results of doubtful use. There is, however, a very great amount of similar work to be done before we shall have even a fair amount of standard data from which to predict industrial processes. His work, however, brings out as nothing else has done the complexity of every-day things that we are prone to believe are simple matters, and they open up a field of almost limitless investigation. All manner of industrial operations that are seemingly simple are just as complex as the cutting of metals, and much investigation must be carried on before we shall be able to predict performances, except by empirical means.

7. *Time study.*—If it is true that the workman lacks exact knowledge of industrial processes, it is even more true that he lacks exactness in estimating the time required to do work. If the statement surprises the reader, let him estimate the time he requires to do customary performances and he will quickly perceive how elusive the time element is and how difficult it is to estimate time accurately.

A good time-keeping system, furthermore, may possibly record the time it has actually taken to do cer-

tain work, but these records do not necessarily show the shortest time in which the work can be done. In fact, the usual cost records show a marked difference of time used by different men or even by the same men in doing a given job at different times. It will be clear, however, that if an instruction card is to be issued with the exactness of that shown in Figure 11, the basic data on which the time allowances rest must be accurate. Mr. Taylor, wishing to secure such accurate data, and being of the opinion that most operations could be performed in less time than they usually were, began to take time observations of machine and hand processes, and out of this work has grown what is now commonly known as time study.

Of course there was nothing new in the idea itself. Time studies were made many years ago and it had long been customary for shop superintendents to obtain time data for the purpose of fixing piece rates. This was done either by reference to the time required to do similar undertakings, or by timing a fast operator either with or without his knowledge. It was not uncommon for the superintendent to have workmen whose confidence he possessed make trial operations which could be used as a base for rate-setting. In some cases this was done openly in an experimental manner and with equipment set apart for the purpose.

These older methods, however, were confined to finding the total time it required to do the work, and the data obtained were useful only for the particular

job in question, or for one very similar. Mr. Taylor endeavored to make observations of the details or subdivisions of each operation, timing the operator even in such small details as in starting and stopping his machine. His contention, which seems warranted, was that many detail operations are common and that if these could be observed with accuracy these observations or "unit times" could be used synthetically to build up time estimates on new work, on which such estimates had not been made. Taken in connection with full information concerning cutting tools and machines, the plan seems perfectly feasible, and in fact some interesting results have been obtained along these lines.

8. *Methods for making time studies.*—Time study in the modern sense consists in finding the time required to perform each elementary detail of an operation, whether these details be mental or manual. The basic idea, of course, is to determine the shortest time in which the operations can be performed and may involve many observations of the same detail operation as performed by skilled workmen. Special methods must be employed for such work, as the time elements may be very small and must be taken with a stop watch and the observations are useless unless taken by skilled observers. It may be well to note in passing that accurate observation of this kind is akin to that required in scientific laboratories and can be properly performed only by those naturally fitted for such work who have already had some experience.

The most common method of making time observations is to mount a stop watch in the upper right hand corner of a board large enough to hold the record sheet and in such a manner that the watch can be readily operated by the thumb of the left hand of the observer who holds the board with his left hand and his left arm, leaving his right arm and hand free to make the records. It will be clear that if the operation being timed requires a considerable time to perform, a few observations will suffice and the error in the observation will be a small per cent of the total observed time. On the other hand if the operations require only a few seconds, many observations must be made. In fact if the time elements are very small, it may be necessary to measure the combined times of a number of successive operations, and by thus measuring various combinations compute the individual elementary times.

Figure 13 shows a time-study sheet in actual use in making time studies of operators on hand work, performing six consecutive operations. Only one observation was thought necessary for operations 1, 2, 5 and 6, but several were required for operations 3 and 4. Lost time is noted in the extreme left hand column and is used as a basis for estimating the efficiency of the worker.

9. *Interpreting time studies.*—It will be clear that it is a difficult matter to measure human motions of short duration with great accuracy, and equally clear that different workers will take different times

for the same operation. The observations recorded for operations 3 and 4 in Figure 13 show the truth of

BINDER NO.

OPERATION Sealing Boxes
MATERIAL:
OP. NO. 17092
BLDG. 54
DEPT. Shipping
REG. NO. 1687 OPERATOR Mary Jones EST. EFF.
DATE Oct. 9. 1917
MACH. SPEED Hand operations
OBSERVER J. Doe

BEGIN 9 21 FINISH 9 46 ELAPSED 25.00 UNITS FINISHED 50 TIME PER 100 UNITS 50.00

LOST TIME	NO. 1 Secure seals			NO. 2 Take from truck			NO. 3 Glueboard			NO. 4 Print seals			NO. 5 Make report			NO. 6 dispose		
	NO. UNITS	TIME	TIME PER 100 UNITS	NO. UNITS	TIME	TIME PER 100 UNITS	NO. UNITS	TIME	TIME PER 100 UNITS	NO. UNITS	TIME	TIME PER 100 UNITS	NO. UNITS	TIME	TIME PER 100 UNITS	NO. UNITS	TIME	TIME PER 100 UNITS
Talked to Girl .62	50	.32	.64	50	1.50	3.00	12	.70	5.83	3	1.01	33.65	50	.38	.76	50	1.01	2.02
Dropped box 1.81							10	.68	6.80	3	1.06	35.35						
Talked to man 1.02							12	.79	6.58	4	1.27	31.75						
Total 3.45							12	.67	5.58	3	.99	33.00						
							4	.41	10.24	6	2.05	34.15						
										6	1.99	33.20						
										10	3.45	34.50						
										10	3.06	30.60						
										5	1.46	29.20						
							5	3.503		9	2.954.0							
AVERAGE TIME AT 80% EFF.	.64			90%	3.00		90%	7.01		85%	32.82		100%	.75		80%	2.02	
AVERAGE TIME AT 100% EFF.	.51				2.70			6.31			27.90			.76			1.62	

REMARKS

FIGURE 13. TIME STUDY SHEET AS USED IN THE EASTMAN KODAK PLANT

the first statement. The question naturally arises as to how these observations shall be interpreted if they are to be used as a basis of fixing rates of pay for

similar operations. Several methods may be used. Thus the minimum observed time is adopted by some time-study men, and an allowance which varies from 25 per cent to 75 per cent of the observed time is made to provide for rest periods, unavoidable delays and personal requirements of the worker. Another method is to take as a basis the observations which occur most frequently. In Figure 13 the average time has been taken as shown at the bottom of the sheet. These average times are corrected by the estimated efficiency of the worker, these corrected times being, therefore, those in which a highly efficient worker could do the task. The sum of these corrected times is the total time that should be required to do the entire series of operations. This summary and such notes as may seem to be desirable are made on the back of the time-study sheet.

The estimated allowances and efficiencies referred to in the foregoing should be carefully noted because they indicate that, as yet, a certain element of good judgment must enter into time study work if the results are to be used in predicting performances and setting piece rates. This in no way detracts from the value of time study, but the exaggerated idea held by many in respect to the exactness of time study is hardly justifiable.

10. *Motion study.*—It has been assumed in discussing time study that the sequence of the operations studied is correct and presumably the best. Time study, however, naturally raises the question whether

the sequence of operations as performed by an uninstructed workman is necessarily the most economical. It has been shown that it is highly economical to plan the sequence of processes in a broad way by routing the work as to machines and processes, since, obviously, by such routing the best sequence can be secured and wasteful movements of transportation can be prevented. The very same arguments apply to a series of operations as listed on the instruction card, Figure 11, and pertaining to the work of a single machine.

It is natural to suppose, however, that a skilled workman will be the best judge of such sequence, and while in simple cases this is probably true, experience has shown that here, again, systematic analysis will often be superior to empirical knowledge. Even in the handicraft callings it has been found that the methods used are exceedingly inefficient, and that great gains in production can be made by rearranging the methods by which the work is performed. The most remarkable instance of this is to be found in the work of Mr. Frank Gilbreth in connection with brick laying.

Mr. Gilbreth found that masons of today were practicing their art in much the same way as their predecessors did on the walls of Babylon. From time immemorial masons have worked from a scaffolding which was raised only when the mason could no longer reach the top of the wall. It was then raised to such a height that he must bend his back

constantly or work on his knees until the wall grew so high as to relieve him of such awkward positions. From time immemorial also the mason's tender has dumped unsorted brick and mortar on the scaffold at the mason's feet so that the mason has to stoop to get both mortar and brick, selecting the brick as he went along, and often working up the mortar with his trowel. Mr. Gilbreth found also that many of the motions made by the workers were useless and used up valuable energy with no effect.

One of his first innovations was to devise a scaffold that could be raised quickly a few inches at a time so as to be kept at or near the best level for economic working. To this was added a shelf-like attachment on which the bricks and mortar could be placed near the workman's hand. The sequence in which the brick should be laid for various types of wall was worked out and in order to save the high-priced mason's time in sorting the brick, low-priced men were employed to sort the brick on the ground. The bricks were sent up to the mason in packets of twenty-four each with the bricks arranged with the right side up so that no sorting was necessary. The mortar was carefully standardized and a special mortar box made it easy for the mason to secure mortar while still following with his eye the hand which held the brick. A careful study of the mason's motions and a rearrangement of methods eliminated about half the motions previously performed. As a result of these changes it was found that the worker could lay about three

times as many bricks per hour as formerly, and with less fatigue.

11. *Refined methods of motion study.*—Motion study like time study involves no new ideas. Long ago these methods were employed in complex assemblying industries where correct sequence of operation would obviously save much time. But the work of Mr. Gilbreth and others has shown that motion study opens up opportunities for great time saving and has accented the fact that even the skilled worker who has learned his calling in the traditional manner is often inefficient and wastes much of his energy in useless motions, tho the final result of his labors may be all that is desired.

Many motions of the workers on rapid work are too quick to be caught by the human eye and segregated from connecting motions. Mr. Gilbreth has used the moving-picture machine to investigate such rapid motion in a very ingenious manner. Near the workman, whose motions are to be studied, is placed a clock of special design about 30 inches in diameter. This clock has a pointer which makes ten revolutions of the dial each minute, the dial being divided into 100 parts so that each division of the dial represents $\frac{1}{1000}$ of a minute. The pointer moves one division in each movement. When the film is exposed a permanent record is obtained of the operator's movement, accompanied with a record of the time required to perform each movement, however rapid. This picture can be studied in detail and any unnecessary mo-

tions can be detected. Mr. Gilbreth has secured some excellent results in this manner. Obviously such a record would be of value in comparing different operations such, for instance, as complex assembling where the motions are many and rapid.

Another interesting method that has been used by Mr. Gilbreth is to fasten a small electric light bulb to the hand of the operator, connecting it to some source of current by light flexible wiring. The light in the neighborhood is lowered somewhat and a photograph taken of the operator's movements by an ordinary camera. The diagram photographed on the plate shows the path of the operator's hand and from this diagram deductions can be made as to whether time can be saved by changing the method or by correcting the workman's motions.

12. *Significance of time study and motion study.*— It should be noted that these methods are refined extensions of old principles. They do not themselves constitute a new philosophy of management, but they are simply efforts to apply the scientific method to the measurement of human effort. They aim to do for management what engineering research has done for the designing department. How far they can be considered to be scientific is a debated question. Mr. Taylor and his followers have always maintained that these methods could be very scientific. Other writers such as Professor R. F. Hoxie [1] claim just as strongly that the personal equation enters into these observa-

[1] See "Scientific Management and Labor," page 40.

tions so greatly as to make accurate and scientific results impossible. Clearly these methods do touch the human side of industry very closely. Mr. Gilbreth himself says they are closely connected with experience, skill, contentment, training, habit, fatigue and other personal matters.

Aside from the merits of such contentions the fact remains that these methods have put into the hands of the employer a measuring instrument that until now he has not possessed. Until now his estimates of output have been based solely upon his own judgment and upon the answers given to his inquiries by his employes. These methods have shown clearly that men in general can produce more than they usually do. Whether these methods are scientifically accurate or not, they are probably here to stay, in some form, and without doubt the general principles involved will be widely used in all industries. For while the results obtained by these methods may be far from scientifically exact, they are far more accurate than the guesses and empirical estimates usually made by foremen and workmen.

Like all other industrial methods they have their limitations. Like the fundamental principles discussed in Chapter II, their economical use is limited by the quantity to be produced. It will not pay to make elaborate time studies unless there are many products to be made, or unless the few pieces to be made involve much work.

13. *Objections to time and motion study.*—Time

study and motion study have not been kindly received by the workmen in general, and organized labor has always vigorously opposed these modern methods. Many reasons have been advanced for this opposition. The best discussion of these objections from organized labor, so far as the writer is aware, is contained in "Scientific Management and Labor" by the late R. F. Hoxie. It is said that it humiliates the workman to be the subject of stop-watch observations, that it makes him nervous, hence he does not do justice to himself when under observation. It is also argued that the results so obtained are not so accurate as the judgment of a skilled operator who has spent years at the work. There may be some ground for the first two claims in the case of some men, but the claim of superior accuracy on the part of the workman has been proved in so many ways to be untrue that it should have no weight. To argue in this manner would be to argue against scientific methods in agriculture, engineering, medicine, or any other calling that has raised, or is now raising, itself from the field of empiricism to a higher plane.

From the conflicting discussion, however, two points stand out clearly. Organized labor naturally objects to these new methods because workmen, like most men, are suspicious of all things new. The workman's experience with modern methods has not always been a happy one, and to many to them innovations are synonymous with change; and change may or may not be of benefit to them. The greatest ob-

jection, however, rests on the fear that these methods will be used to drive them to greater and greater exertions without adequate reward. For this reason the introduction of these new methods has proved difficult in many places. On the other hand there are many recorded instances where the management has approached the problem with openness and candor and has succeeded in winning the confidence of the workers, with the result that both sides have been greatly benefitted. Other recorded efforts have not proved so fortunate.

REVIEW

Indicate the special functions in an up-to-date factory of the gang boss, speed boss, inspector, repair boss and disciplinarian.

Show how the production manager may keep in direct touch with each operation at all times.

If you were in charge of production in a shoe factory and needed a heeling machine, what characteristics of the machine would you consider before purchasing?

What big lesson is taught in Taylor's experiments by which he gathered data on the art of cutting metals by machine tools?

How are time observations to be interpreted if they are to be used as a basis for fixing rate of pay for similar operations?

What is your opinion of the efficacy of time study and motion study? What are the principal objections offered by those who oppose such observations?

CHAPTER X

STANDARDS

1. *General.*—The principles underlying standardization and the effect of it on industry in general were briefly discussed in Section 6 of Chapter III. Standardization, it was seen, may be resorted to either to secure interchangeability of product or economy in assembling, or so as to be able to supply repair parts that will fit accurately. Or, again, standardization may be resorted to in order to increase the number of parts of any kind to be produced by decreasing the number of the kinds or sizes, thus more fully securing the benefits of mass production. The advantages and disadvantages to industry as a whole were briefly discussed in Chapter III.

2. *Standards of form and size.*—The standards discussed in Chapter III have for their object the fixing of the form or the size of the product. Thus the manufacturer elects to manufacture electric motors of certain definite capacities, or he produces shoes in certain lengths and widths, basing his deductions on the law of average and expecting to produce sizes of product that are most in demand. It will be clear, however, that standards of this kind are more or less arbitrary and that there is considerable latitude in

their choice. Thus there is no particular virtue in the standard of measure that we have adopted and named one yard. It might be a little longer or a little shorter and be equally serviceable. A motor which is standardized at 7⅝ horse power should be equally serviceable as one standardized at 7½ horse power. The standard dimensions that have been adopted for collars, coats, shoes and a multitude of manufactured articles have been fixed by more or less arbitrary methods. They all represent an approximate solution of an industrial demand between certain rather indefinite limits of that demand, and the field covered by one standard size laps over that covered by the standard size both above it and below it. The fixing of standards of exchange or of interchangeability is, therefore, a somewhat arbitrary matter, while the skillful fixing of standards of form or size for manufacturing purposes depends on a knowledge of the industrial field. Thus Mr. James Hartness in designing his famous flat-turret lathe standardized on a machine that would work bar stock two inches in diameter and 24 inches long, his knowledge of machine processes leading him to believe that a machine of this size would be more useful than one larger or smaller. Experience has proved the accuracy of his opinion.

3. *Standards of excellence.*—But it often occurs that there are certain combinations of form, size, quality, conditions or other circumstances that are the best that can be selected for a given purpose. Thus

there are many makers of boilers who may all produce a standardized boiler of a certain nominal size. The particular form of the boiler built by each shop may vary widely, tho all may conform to the standards set by state or national laws. The efficiency of these boilers in burning coal and transforming the heat thus created into steam, may also vary considerably, and the performance of the boiler which shows the highest efficiency may be selected as a standard of excellence for all boilers of that size. A certain piece of work may be performed in several ways, but there may be one sequence of operations that produces better results than any other. Such a sequence may be adopted as a standard method. Experience may show that an operator will perform more and better work with a given tool, and this tool may be adopted as a standard tool for that process. A rapid workman may do a certain piece of work in a given time, and this time may be used as a standard for judging other records of performance. In textile industries it is found that the best work can be done only when the temperature and humidity are kept at certain points. These conditions, once determined, may be adopted as the standard conditions under which the work is to be done. Many other illustrations of this kind of standard might be quoted, tho the advantages of using standards are not widely appreciated.

It should be noted that an article that has been standardized in form or size may be built in several standards of excellence. Thus an electric motor of

a given capacity may be built to give a high or a low efficiency in performance and a shoe of any given size and model may have widely varying wearing qualities, according to the material and workmanship. It may not be necessary or desirable, furthermore, to seek only the highest standard of excellence in all cases. It may be desirable to make shoes of a given size and model in several grades of excellence. If only the highest grade of phonographs were manufactured, a much smaller number of people could enjoy them. It may be necessary to build an article of highest quality for one service, while the same article, of inferior excellence so far as form and size are concerned would be equally serviceable elsewhere. It is usually important, however, that all articles of a given form and size shall be fully up to the standard of excellence set for that particular article, whether that standard be high or low. A few illustrations of the applications of these several standards to various industrial activities may make their uses and advantages clearer.

4. *Standards of administration.*—It was shown in Chapter III, Section 6, how standardization of product as to form and size is an administrative necessity in order to utilize more fully the principles of mass production. But administrative standards may also be set up that concern the personnel of the organization. In the older forms of organization separation of function on the part of executives was accidental and the duties which each officer performed were

often vague and overlapping those of other officials. Often the officer did not understand his duties exactly, nor did he know the extent of his authority. A modern organizer will define the duties of each officer by an organization chart (see Figure 4) which will often suffice to show clearly what the relations are between men and departments. If this is not sufficient, he will make a written statement defining exactly the functions of each officer so that no misunderstanding can arise concerning these matters. These statements are sometimes bound together, forming an administrative record book. This procedure is one of standardization of form or type since it virtually prescribes the content of each officer's duties. It does not specify the efficiency or excellence with which he is to perform these duties.

5. *Engineering standards*:—The engineering department is necessarily concerned with standards of all kinds. First, it will naturally be expected to determine and maintain the standards of size and form necessary for interchangeability if this is desired, and to fix all limiting dimensions necessary to this end. The engineering department must necessarily also determine largely the type and sizes of product which are to be standardized and to fix the dimensions and forms of all parts of standardized machines. This department should also carefully standardize its own work. Thus all drawings should be made on sheets of carefully standardized sizes; all engineering instructions should be issued on standard forms; stand-

ard methods of lettering and of titling drawings should be adopted, and a system of standard nomenclature for all drawings and manufactured parts suitable to the needs of the factory should be worked out. A brief description of such standard nomenclature is given in Chapter IV of the volume on "Cost Finding."

More important still, perhaps, the engineering department must specify the standards of excellence of the product and often should share in the responsibility of maintaining that excellence thru supervision of some of the features of inspection. (See Chapter XI.) The selection of the standards of excellence, however, cannot be left always to the discretion of the engineering department. A good engineer and a good designer naturally want to make only the very best product. Manufacturing, however, is a commercial undertaking and standards of excellence must often be fixed with reference to the market. The sales manager and the general manager, therefore, in consultation with the chief engineer, are more likely to arrive at a wise conclusion regarding the quality of the product than is any one of them, if undertaking this problem alone.

For similar reasons the engineering department cannot always be trusted in the matter of changing standardized lines of product. If the engineering department is a live and active organization it will naturally wish to put new designs upon the market. Such a procedure may be very costly if it means the discarding of many costly special tools that have been

made for the product that is to be displaced, especially if they have not paid for themselves in actual production. Engineering changes in standardized lines of product should, therefore, be carefully considered before putting them into effect. This particular phase of modern mass production is a difficult one, especially in an industry that is growing. How far, for instance, can a manufacturer of automobiles change his product yearly so as to keep up with engineering progress and popular fancies without going bankrupt by scrapping special tools? Problems of this kind require the most careful attention on the part of the administrator, and they are not solely engineering problems.

6. *Standard materials.*—The necessity of standard specifications as a basis of purchasing has already been noted in the chapter dealing with that subject. Such specifications presuppose that the materials purchased have been carefully selected for some particular purpose. The advantage and economy arising from standardization of all materials used is not widely appreciated. In many cases the decision as to the quality of material to be used is left to the storekeeper or to the foreman in charge of the work. In small enterprises or in shops doing repair work the judgment of such men may be sufficient. Yet, obviously, better product and lower costs will result from an effort to have the proper material used in every part. This does not mean that the best of material should be used in all cases, but it does mean that

when a certain material of a certain quality has been carefully selected for a given purpose, care should be taken that this quality is adhered to.

Much money can often be saved by reducing the number of kinds of materials and by reducing the number of sizes or forms of each kind. Not only does standardizing the material used make purchasing more effective thru securing larger quantity, but it reduces the danger of having special material left on hand to tie up capital and to depreciate. The engineering department can usually save much money by a careful standardization of all material used in the product, both as to form and size and also as to the quality of the material.

Advantages of even greater value accrue from standardization of supplies. These should always be bought only after careful consideration of the purpose for which they are intended, and after standard specifications have been prepared. All these considerations gain in importance as the plant increases in size and as the number of lines of product becomes greater.

7. *Standardization of quantity.*—Great economies can also be effected by carefully prescribing the amount of material that is to be used. In repair work, again, the economic use of material becomes a matter of personal vigilance, but wherever work is to be repeated, the quantities should be worked out with care and standard bills of material made which will serve both as a basis of purchasing and as a

basis on which material can be withdrawn from stores. If possible, such standard specifications should be made by the engineering department, as such specifications will necessarily be more accurate than if made by the production clerk who is not so well informed concerning the product as is the engineer. In any case the standard requisition should be filed so as to be available for future work. A very good plan is to place standard bills of material on the drawings, tho this is not always convenient.

Standardization of the amount of supplies used is also a source of great economy. In large works such materials as waste for cleaning machinery, oil, brooms, etc., can often be issued on a budget system, each man receiving periodically what he needs according to his duties. It is a comparatively simple matter to standardize the amount of coal that should be burned in the power house for a given amount of power generated or to establish standards for the use of gas, chemicals or other materials that may be used in industrial processes. If these standard amounts are exceeded, some good reason should be given for such excess. A later section will deal with the methods by which records of the use of materials can be obtained and comparisons made with the established standards.

8. *Standard methods.*—It has already been shown in Chapter IX how the work of Mr. Gilbreth has made it clear that the method or sequence of processes selected by a skilled worker is not necessarily the best.

Mr. Taylor's methods, which are discussed in Chapter VIII, involve the planning of all productive operations in advance and in giving the worker a written instruction sheet directing him as to the exact sequence of processes. This it will be noted virtually standardizes the method of procedure by selecting from the many possible methods the one which appears to be logically the best. This idea of standards contains great possibilities especially in assembling a small manufactured product which consists of many parts. It will be obvious that the work of assembling a watch or a kodak or an arc lamp can be greatly facilitated by an orderly and logical procedure; yet one often sees the assembly of complex products of this kind left to the judgment of a busy foreman or, worse still, to the initiative of the workmen themselves. Careful planning and standardization of the methods to be pursued will often produce remarkable results in work of this kind, and the idea is of very wide application. In a larger way this same idea of standardized method appears in the arrangement of the machinery for continuous processes where obviously there is only one best way to proceed.

9. *Standard tools.*—While American manufacturers have been the strongest advocates of standardized product, they have been very backward in standardizing the tools in their own shops. This is particularly true of the iron-working industries. It is common to see in the same shop a group of lathes, all of the same nominal size and capacity but made by dif-

ferent makers and markedly different in construction. One has a lead-screw with six threads per inch, another has four threads per inch. One has change gears with the number of teeth based on multiples of ten, while its neighbor's gears are based on multiples of twelve. Competition and a rapidly growing art have brought about these variations.

While such variations in machines of the same size may be of no importance in shops doing only repair work or in those where the work is of great variety and size, they become a serious disadvantage when work is planned in advance. Thus it will be clear that in making an instruction card (Figure 11) a great saving in time and expense can be secured if all machines of the same nominal size have the same characteristics. It will not be surprising if the demand for standardization of this kind in the near future will result in manufacturers adopting standard characteristics for similar product, just as steel manufacturers have standardized steel rails.

These general principles hold true for small apparatus, such as cutting tools. There is no reason why there should be an infinite variety of cutting tools. Several standard sets have been evolved and special grinding machines are now in the market which will not only keep these standard tools in good cutting order but will grind them to the required standard shapes. There are many lines of work where these standardized tools can be used to great advantage and there is a wide field for the application

of the principle to small apparatus in general. In large tool rooms, for instance, many small parts used in constructing special tools can be standardized. There is no reason why the steel bushings used for guiding drills in drilling fixtures should not be made in standard sizes where many are used.

Nor is the application of this principle confined to the tools furnished by the employer. It will pay any employer to examine carefully the hand tools that are the property of the workman. While it is true that workmen often work most advantageously with the tools with which they are familiar, it will often pay the employer to replace the worker's personal tools with better equipment. In many instances it will pay the employer to furnish standard sets of tools at his own expense. The same argument holds for more personal equipment, such as goggles, shoes, etc., where the work is dangerous to life and limb.

A certain American manufacturer recently opened a large factory to be operated almost entirely by women. He had a high-priced costumer design a set of garments of rather new fashion perfectly adapted to the work, yet pleasing in appearance, which he furnishes free to all women workers. He will probably be more than repaid by a lowering of his compensation liability from accidents.

10. *Standard performances.*—It was shown in Chapter VII that it is possible to measure the time required by a workman to do a given piece of work, and it would seem, therefore, that such measured re-

sults could be used as a basis of setting standard times for performances. If the operation is one that is performed largely by a machine or process and is not dependent to any large degree upon the strength or skill of the operator, there is no doubt that quite accurate records can be obtained by these modern methods and can be used for setting the time of performance almost without regard to the characteristics of the worker. If, however, the personality, skill, or strength of the worker is involved in the measurement, the problem is more complex. A discussion of this feature of standardization will be discussed more fully in connection with the personal side of industry.

11. *Standard conditions.*—An important feature in the attainment of standards is standardized conditions. This is well illustrated in the case of textile mills where the attainment of standard product depends largely upon the maintenance of standard conditions as to temperature and humidity. The principle holds, however, in all industry. An automatic machine, being impersonal, cannot make a standard performance unless it is in as good condition as when the standard performance was made. If the driving belt is slack or if the tools are dull, or if the machine and works are not properly lubricated, it is not reasonable to expect the same result as when these factors are up to standard conditions. These relations are even more marked wherever the human element is involved, since men are sensitive to their surround-

ings. A workman cannot make fine measurements with cold fingers, be he ever so ambitious, and all are aware of the difficulty of performing wonted tasks in the presence of new and distracting influences or in strange surroundings.

The truth of these statements is proved by an examination of any set of costs covering the production of successive lots of product, all presumably made by men of the same degree of skill and upon machines of the same size and kind. The variation in such costs is well known, tho the reasons for it are often difficult to find. Allowing even for the variations in personal effort under ordinary conditions as prevailing in most shops, careful attention to the conditions under which men work, the character of their equipment and similar efforts would no doubt eliminate some of the wider variations in costs.

12. *Other standards.*—Many other standards could be enumerated. Thus efforts have been made to establish standards of efficiency for workmen, wage standards, standards of employment, and others affecting the personal relations of the employe. These will be discussed so far as may be necessary elsewhere. Inspection standards are discussed in the succeeding chapter.

13. *Permanence of standards.*—It was noted in Chapter III that standardization tends to crystallize methods and processes, and thus retard progress. For that reason standards should be chosen with care. The great illustrations of this effect are found in our

standards of exchange in weights, measures, money, etc., and in such engineering standards as screw threads, the gauge or distance between railway rails and similar standardized matters. It would be difficult indeed to change some of these standards, tho even now some of them are outgrown and could be improved. The standardization of machine tools that has been suggested in Section 9 might also result in retarding progress in this art, tho there might be compensating gains in production.

A clear distinction should be drawn, however, between standards of such universal use as these and standards that are peculiar to the particular industry or factory under consideration. Standard designs, standard methods, standard tools and standard conditions, as here understood, are simply the best methods, tools, conditions, etc., that can be devised at the time for accomplishing a given object and are subject to change whenever better ways and means can be found.

Standard methods furthermore do not imply that the highest degree of excellence is sought. It may be just as important to develop standard methods for a very cheap machine as for one of the same design but of greater excellence. The conditions in a manufacturing establishment are also somewhat different from those in industry in general. The special tools that tend to prevent progress necessarily wear out and must be renewed and the sequence of processes can be changed at will. There is usually ample oppor-

tunity for making changes in standardized product without great loss thru discarding special equipment, tho care should be exercised that changes are not made simply for the purpose of making changes. There is nothing inherent in the principles of shop standards, as discussed in the foregoing, that prevents a reasonable amount of progress. The highest degree of excellence, in fact, is frequently found in highly standardized product, such as electrical apparatus, where long experience in making many machines coupled with steadily rising standards both in design and in shop methods have produced machines that are nearly perfect for their purpose.

14. *Effect of standards.*—The objections made by some writers, therefore, that standards exercise an injurious effect upon the quality of product and that "they tend to make the kind of product that can be made by the mile and cut off in lengths" are based on a misconception of manufacturing methods. These arguments also imply that nothing but the very best should be produced. The author would take direct issue with this view. Modern society has need of many grades of product. It is better that all men should have certain books, for instance, tho they are cheaply bound, than that only a few people should have elegantly bound copies of the books. Those who have the money to pay for special, highly finished articles have had no trouble as yet in satisfying their wants. There will always be a market for the highest hand skill, as in painting and carving, but that

market will be even more narrowly defined as time goes on.

What standards really do is to insist on a definite form, quality or performance, as the case may be, in accordance with the standards selected. They thus tend to raise the average excellence to the maximum demanded by the standards set. This effect is common knowledge with all men who have had experience in mass production under modern methods.

As to the charge that standardization, by retarding the use of new patents and improvements, robs the consumer of the benefits of these innovations, it should be remembered that if a manufacturer is compelled to discard valuable machinery in order to manufacture an improved product before this machinery has paid for itself, this loss must be paid by some one, and this some one, in all probability, will be the ultimate consumer. For this reason it may be good policy to move slowly in such matters. When one considers the wonderful facilities and implements such as telephones, typewriters, phonographs, bicycles, etc., that modern standardized production has made possible in the last decade or two, there would seem to be little to worry about so far as retardation of development is concerned.

REVIEW

Why has standardization in production become of such importance during the last decade?

How may a manufacturer of automobiles keep up with engineering progress and the fancies of the public without scrapping special and costly tools and machinery?

Is it possible to apply standards to the human element as we do to machinery? May administrative standards be set up for the duties of the officers in an organization?

How will the use of standardized tools hold production to the highest possible level?

What arguments are made against standardization? In answering these objections, state the principles which should guide every manufacturer in adopting new standards.

CHAPTER XI

THE CONTROL OF QUALITY—INSPECTION

1. *The attainment of standards.*—In the preceding chapter the characteristics of standards were described and also the general methods by which standards of several kinds were defined. It should be carefully noted that standards are theoretical ideals that are difficult to realize absolutely in practice. It is difficult, if not impossible, to buy large quantities of materials of absolutely uniform quality and of the exact quality called for by the purchase requisitions. Even with the best precision tools that we now possess, it is exceedingly difficult to make a large number of parts that will be exactly alike and of the exact dimensions called for on the drawing. It is very difficult to build a single machine that will perform its functions exactly as predicted by the designer, and exceedingly difficult to build a number of machines that will give exactly the same performance. Absolute accuracy is virtually unattainable in practice. In practice, therefore, theoretical standards must be replaced by practical standards which will indicate how far the product may vary from the theoretical standard and yet be satisfactory.

Nowhere perhaps is greater precision sought than

in the coinage of money. Yet as perfection cannot be obtained, there are narrow limits of variation established by law both for the fineness and weight of coins. Thus in the United States gold and silver coins are 900 fine but there is permitted a variation of $\frac{1}{1000}$ for gold and $\frac{3}{1000}$ for silver coins. Gold coins produced by the mints in 1916 were found by the Assay Commission to vary in extreme cases from the theoretical ideal by only $\frac{3}{10,000}$ above it and $\frac{5}{10,000}$ below it. In the same manner there are legal limits of weight. Gold coins may vary by $\frac{1}{2}$ grain from the prescribed weight, silver coins by 1 grain, nickel coins by 3 grains and the bronze cent by 2 grains. For the twenty-dollar gold piece the variation permitted is only .00097, for the five dollar piece .00388. On the other hand for the nickel five-cent piece and for the cent the variation of weight permitted is about four per cent. The greater deviation permitted for coins of lesser value, illustrates the fact that the degree of accuracy required may vary with the circumstances of the case.

The variation from the theoretical standard that may be allowed will vary greatly with conditions. In rough work considerable latitude may be permissible in quality of material, workmanship and finish. In other work, such for instance as the manufacture of military rifles where a high degree of perfection as to interchangeability is imperative, the dimensional variation that is allowable in the several parts is exceedingly small and satisfactory results difficult to

obtain. The experience of American rifle and munition makers during the last few years has furnished ample evidence of this last statement. Furthermore, the time and consequent cost of production increase rapidly as the limits of variation approach the theoretical standard.

2. *Inspection in general.*—Inspection is the art of comparing materials, product, or performance with established standards. These standards may be fixed for different reasons or by different people, but obviously there cannot be intelligent inspection without standards of some kind. It has been shown that even with the best of tools and with careful workmen some parts will fall outside of a liberal allowance of error from the established standard; some will be well within the limits, while still others will be very close to the limits. Inspection is the art of selecting from these three classes of product those parts that will be satisfactory for the work in hand. If the limit of variation from standard is very close, this may be a delicate and difficult operation. Conversely if the variation permitted is large, less difficulty will be experienced in selection.

It should be noted, however, that this selection introduces the personal element. Some person or persons must decide whether the part or piece of material or quality of finish is near enough to the required standard to be acceptable. Absolute perfection is not to be expected in any of these matters. There is therefore no part of productive industry that re-

quires such keen judgment and knowledge of the work in hand combined with good common sense as the work of inspection, particularly where the limits are exceedingly small, as in mass production of fine product.

3. *Growth of inspection methods.*—It will be clear that inspection methods can be applied in connection with any of the several kinds of standards discussed in the preceding chapter. In general, however, inspection methods are mostly concerned with the quality, dimensions and finish of materials during the several stages of fabrication, hence the discussion will be confined for the present to that phase of the matter. The necessity of carefully inspecting purchased materials has already been referred to and will form the basis of a succeeding section.

In small factories it is still common practice to use the final assembly of the product as a check against poor workmanship and to depend upon the skill and reliability of the individual workmen to produce satisfactory individual parts. It is customary also in such plants to use the final running test of the apparatus as a criterion of the fitness of the materials. Obviously no such chances can be taken in mass production, especially where under modern intensive methods the great stress laid on quantity is always a menace to quality. This is common experience; any speeding up of productive processes must be safeguarded by careful inspection tests upon the quality. A good modern inspection system will, therefore,

check all material step by step from the time it arrives at the storeroom till it is shipped from the factory. The detail in which it is necessary to inspect material in the several stages of fabrication will necessarily vary with the circumstances.

4. *Division of responsibility.*—Inspection may involve the following characteristics of materials: Quantitative, or as to the quantity or number of pieces; qualitative, or as to the physical or chemical properties of the materials; dimensional, or as to the accuracy of form of parts; appearance, or as to color, finish, etc.; salability, or as to the fitness of the product for the purpose for which it has been constructed.

Since the responsibility for meeting these requirements usually falls on different divisions of the factory, it is not convenient or desirable, in general, to have all inspection done in one department or by one body of men. In most large plants these duties are divided into three distinct divisions, tho the work of these divisions may at times overlap each other to some extent. Purchased material is usually inspected under the supervision of the storekeeper, tho in large plants this work may form an independent function under the purchasing agent. The inspection of work in process as to dimensional, or other manufacturing requirements, is usually conducted by the shop inspectors who are organized directly under the superintendent or general manager. Final inspection of the finished product as to performance, capacity, etc., while usually conducted as a separate function, is

sometimes directly under the superintendent, or works manager. Where the product is complex and involves scientific principles, it is much better to place the final inspection and test under the engineering department. The particular arrangement of these three phases of inspection will necessarily vary with the shop and with the product produced.

5. *Inspection of purchased goods.*—The importance of inspecting raw material and the general methods by which this is accomplished have been noted already in Chapter VI, Section 10. The necessity for adequate standards and the importance of setting working limits for these standards, as discussed in Section 1, are of prime importance in inspecting purchased goods. Thus in purchasing ordinary screw bolts, a visual and manual inspection of the fit of the nut on the screw thread is usually adequate, since perfection of fit is not necessary. In purchasing very small taps for instrument work and the screws that are to be used in connection with them, the problem of inspection is markedly more difficult. Here the limits of departure from standard are very small. If the screw is a few thousandths small, it may rattle loose and if it is a few thousandths large, it may twist off in driving. Specially designed calibrating devices must, therefore, be used for inspecting such purchases. Usually such devices are fitted with a magnifying device so that the departure from standard is shown on a large scale by a needle which moves over a graduated scale.

In a similar way refined methods of testing the chemical and physical properties of purchased materials may be necessary. Many large plants have large and well equipped testing laboratories attached to the receiving department or purchasing department for carrying on these tests. A certain concern that purchases many small springs, not only tests the strength and deflection of every spring purchased, but gives an endurance test to samples of each lot in specially designed test machines which extend or compress the samples tested a sufficient number of times to insure sufficient longevity of service. Another company tests samples of all metals purchased on a special testing machine which subjects the sample to sufficient repetitions of stress to produce rupture, thus giving a measure of the probable life of the material under actual operation in a machine.

The limits of departure from standard are highly important in purchasing. If they are set closer than is necessary, the purchasing agent will have to pay more than is justifiable under the circumstances. If set too liberally, imperfect material may be purchased.

6. *Basis of inspection during fabrication.*—The basis of inspection during fabrication can perhaps be well described by quoting from the author's "Principles of Organization" as follows:

> Under the older and cruder methods machine parts were made as accurately as the tools available would allow, and the discrepancies adjusted with the file or other hand tool at assembly. Today, with the demand that exists for inter-

changeable parts, such hand work cannot be tolerated and with modern machine tools and measuring appliances it is not necessary, provided all parts are carefully inspected when made. Furthermore, it is more economical where there is any considerable quantity, to spend a little more time in insuring accuracy in detail parts thereby saving the annoying, and expensive corrections so often experienced in assembling.

Inspection during the process of manufacture therefore should be organized with the following considerations in mind:

(a) To prevent unnecessary hand work on the assembly floor.
(b) To inspect mass-production operations in the beginning and often enough thereafter to prevent any great amount of material from being spoiled.
(c) To prevent further work on parts that are already spoiled.
(d) To see that no parts are lost in transfer from process to process and to see that all are accounted for.
(e) To see that pay is given only for good work.
(f) To locate imperfections in machines and processes and lack of skill on the part of the workmen.
(g) To guard against the natural tendency of intensive production to cause a lowering of the standards of accuracy.

7. *Inspection in mass production.*—It is obvious that the accuracy of production will depend largely upon the accuracy of the tools furnished and upon the skill of the workman. If a skilled worker is provided with high-grade precision machines, and with standards and gauges that are correct and are so maintained, he can produce very accurate work. Inspection of such product should not be difficult even with close limits of variation. This combination, however,

is seldom found in practice. Modern mass production aims to produce high-grade product with machines of high quality operated by men of low skill. This combination may or may not produce very accurate work.

One of the most common methods of securing accurate work in this manner is by the use of limit gauges. Figure 14 illustrates a limit gauge such as might be furnished to an operator who was grinding cylindrical parts. It will be noted that the outside measuring points are set at .00025 of an inch above two inches while the inner pair of points are set at .00025 of an inch below two inches. If the piece to be measured will pass between the outer pair of points, but will not pass between the inner pair the maximum variation from 2″ will not exceed .0005″. These limits are not uncommon in practice and it would seem to be a comparatively easy matter to machine a part that would fulfill these requirements. The difficulty arises in the extremely small limits and the delicacy of the operation.

Obviously such refined measurements will be affected by changes in temperature. The limit gauge shown is fitted, as will be noted, with a rubber gripping piece so that even the temperature of the operator's hand will not distort it. It will be clear also that the delicacy with which the gauge is applied will greatly affect the measurements. In other words, even with these instruments which embody the most refined transfer of skill that is known, the human ele-

ment still enters in and cannot be overlooked. The gauges furnished to the operator are sometimes set a little closer than those used by the inspector in order to insure that the work will be produced within the desired limits.

The selection of limits for refined manufacturing,

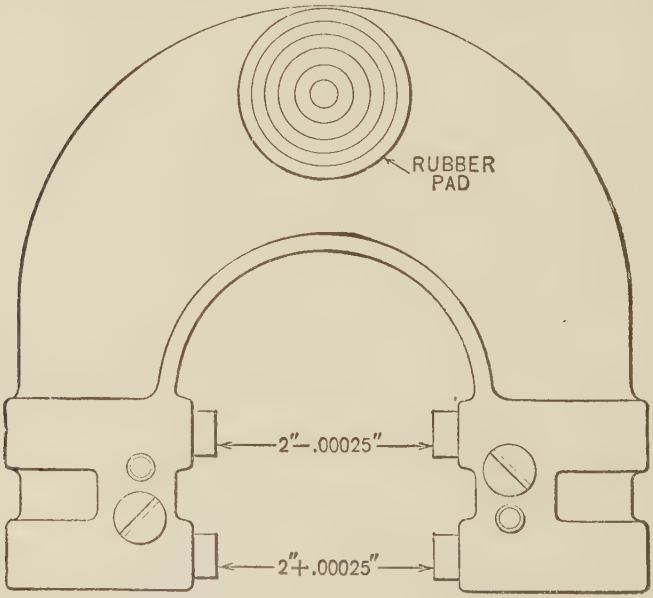

FIGURE 14. JOHANSSON LIMIT GAUGE

such as is illustrated in the foregoing, and the "tuning up" of a large factory to produce thousands of parts to these limits of accuracy is not a thing to be entered into lightly. It is, in fact, a fine art; and managers and owners will do well to consider carefully the possibility of securing such workmen as may be

necessary for accurate production before embarking on such an enterprise. Under no circumstances should it be attempted without experienced inspectors and first-class inspection equipment. It is axiomatic in mass production that the first parts produced by every machine or process should be inspected with very great care before proceeding to manufacture. It is also essential that a full set of parts be carried thru to completion and assembled before production begins, thus testing out all machines and fixtures. And constant vigilance is necessary after production begins, to see that all machines are kept in adjustment and all gauges are kept right up to standard, all wear being compensated for.

8. *Unit Inspection.*—In many machines there are groups of parts that can be assembled as units, each unit being treated as an individual part in the final assembly of the machine. Often it is not necessary that the component parts of these units shall be interchangeable to a high degree of accuracy, as the unit is replaced or repaired as a whole, tho it may be essential that the units as a whole shall be interchangeable with each other and in their relation to other parts of the assembled machine. Much saving can often be effected by lessening the rigidity of inspection of the parts comprising each unit except in so far as the relation to the assembled machine is concerned.

9. *Relations of inspection to the workman.*—A good inspection system will keep account of all work delivered to each workman and will detect any work

that he may spoil. Each man should be held strictly accountable for the accuracy of his product, and the matter of spoiled work should be settled on the spot and at the time of delivery. In settling such matters great care should be exercised that no blame is placed upon a workman for errors that may have arisen from faulty gauges or faulty instructions. A record should be kept of the work spoiled by each man; for even tho no penalty is exacted for such spoiled work, such records have a good effect on the morale of the workmen.

It should be remembered, also, that good gauges and good machines alone cannot produce accurate work, and the main function of inspection is not to fix blame upon some one but to find the cause of the error as quickly as possible so that it can be remedied at once, whether this involves adjustment of apparatus or instruction of the worker. It is better in most cases to assist a workman to remedy his defects, thus preventing a recurrence of the error, than it is to be satisfied with reprimanding him or discharging him, perhaps to repeat the performance with a new man.

10. *Quality versus quantity.*—The demand for large quantities of product is always a menace to the quality. It is common experience in all lines of production that speeding-up the production is likely to result in inferior product unless very great care is taken to provide against this tendency. Before any such speeding-up is attempted, therefore, careful consideration should be given to the matter of inspection and

proper provision should be made in the way of gauges and means of applying them. This is surely a case where "haste makes waste."

Great pressure is often put upon the producers to increase their output by paying them bonuses for such increases. While this may be advisable, there would seem to be no reason why a bonus cannot also be paid for keeping up the quality as the quantity is increased. While such a plan might retard the increase in quantity somewhat, it would increase the percentage of parts that are fully satisfactory from the viewpoint of the inspector.

11. *Other forms of inspection.*—The foregoing discussion has dealt with the most refined methods of production and inspection. There are, of course, many other phases of inspection that are not so refined and which cannot be conducted with measuring instruments. Thus color and quality of finish are perhaps best specified and inspected by means of samples. The inspection of shipments to see that they are properly packed and crated will call for good judgment and knowledge of such matters. The field of inspection, in fact, covers a very wide range and like all productive activities will demand specialized knowledge or judgment depending upon the work in hand.

12. *Organization of the inspection department.*—It will be clear from the foregoing that an inspection department, if it is to be an effectual check upon waste and poor work, should be organized apart from

the manufacturing organization. In most cases, therefore, the chief inspector is placed directly under the factory manager. Inspection by the foreman or by any one under him is likely to be lax, if not partial, since the foreman is, to a large degree, responsible for defective work. In small shops especially, where interchangeable work is not required, inspection by the foreman is often sufficient, but this arrangement will not do for mass production.

In most factories a simple line organization of the inspecting force is adequate. The chief inspector in such cases will have a foreman-inspector under him in each shop and each foreman-inspector will have such inspectors and assistants as may be necessary for effective inspection. In large factories this organization can be improved by providing the chief inspector with a small staff of experts. These expert inspectors will have no executive authority over the foreman inspectors, but will act as advisers and instructors in the particular phases of the work on which they are specialists. Such an arrangement provides, therefore, for staff instruction of all inspectors, but is also a great aid to the chief inspector in checking up the work of the entire department by providing an inspection of inspection.

The inspector himself should be a man of firmness and decision, yet he should be absolutely fair in his judgment. His duties are judicial and not productive and his business is to find errors and mistakes and their causes; and while he should not be responsible

for removing such causes, his suggestions in this direction may be valuable. He should, above all, have a large amount of plain common sense, know when to enforce the standards rigidly and when the requirements may be relaxed. Not all dimensions of a given part may need to be absolutely up to a given standard; yet in many instances inspectors have been known to condemn large amounts of material because some non-important detail was not exactly as called for on the drawing. Inspection that is too lax causes poor work; inspection that is too rigid may waste much good product.

13. *Methods of conducting inspection.*—There are two principal methods of conducting inspection, namely, by traveling inspectors and by centralized inspection. The first method is well illustrated by the method in which the foreman is depended upon for inspection. He inspects the work wherever it may happen to be, regardless of size. But even when an official inspector is installed, this method must sometimes be used. Where the parts to be inspected are large, it is obviously necessary and economical for the inspector to go to the work, just as in heavy machinery it is economical to move the tool and not the work. Such an inspector spends all his time on the machine floors or erecting floors, moving from place to place as may be necessary, checking up the first parts that come from the machines and checking up the finished lots both as to quality and quantity as they arrive or leave machines or processes. In

large works such a travelling inspector may be assigned to each shop, and special tables or platforms may be provided on which to collect quantities of finished product which he may examine on his periodical visits.

When the parts to be inspected are small and numerous, the centralized method of inspection is more economical and more efficient. In this method central inspection rooms are established and all work to be inspected is turned into these rooms. Here the inspectors may work undisturbed by shop activities or influences. Where the parts are very small and must be carefully inspected after each operation, this method has peculiar advantages. The parts to be inspected can be placed in trays which hold a fixed given number and are, therefore, self-counting so that a continuous record of losses and errors in production is easy to obtain. Small instrument work is usually inspected in this manner.

The decision as to which method shall be used or what combination of methods shall be used is, of course, one of administrative judgment. In general if the parts are small and the work of transferring them to and from the inspection room is not too great, centralized inspection will be cheaper and the work will be more accurately done. Centralized inspection, however, may not be so effective in forestalling bad work as the traveling inspector system, without the loss of considerable time in getting sample parts thru the central inspection room.

14. *Inspection of performances.*—Where the product is simple, the final inspection as to performance and suitability of purpose can often be safely left to the production department, but where the product involves refined scientific principles and high standards of performance, this phase of inspection is usually under the engineering department. The final test may cover the verification of scientific predictions and may include physical tests of the strength of the apparatus. Such tests can be made only by trained engineers.

Sometimes the requirements of the final test are set by the purchaser thru purchase specifications, and the purchaser or his representative may be present at the final test with the right of collecting such information or data as he may desire. This authority may often be delegated by the purchaser to great advantage. Builders of boilers, for instance, will now furnish a paid-up insurance policy in certain insurance companies insuring the boiler against explosion for a limited time. Such a policy is a guarantee that the boiler has been built under the supervision of this particular insurance company and according to their rules of construction. The United States Government and other governments always have their own inspectors inspect all material and apparatus going into government contracts made with private concerns. In taking a contract great care should be exercised that the performance requirements and tests are such as can be attained with the apparatus con-

tracted for, and if attainable that the expense of attaining these requirements shall not be so excessive as to cause financial loss.

REVIEW

What relation should practical standards in production bear to absolute or theoretical accuracy?

Since the ideal or perfect inspector does not exist, what characteristics in men should be considered in selecting the most practical inspectors?

What advantages has the system of inspection which checks material in the process of fabrication step by step over the old system of inspecting the finished product?

What division of inspection should be made in a factory in order that the best results may be obtained? What characteristics of materials should be inspected?

Does "speeding up" always mean increased worth-while production?

Do you think that the high percentage of inferior products made for the government under war contracts is due to too much "speeding up"?

What is meant by centralized inspection? When may it be carried on advantageously?

CHAPTER XII

REWARDING LABOR—OLDER METHODS

1. *General.*—The problem of compensating labor, or the labor problem, as it is commonly called, is by far the oldest and also the most perplexing problem of the industrial field. History is filled with the story of the struggle between master and man. Even when the relations between them were very simple, an amicable adjustment of this problem which is as old as organized society was not reached without much friction. Twenty-three centuries before Christ, Hammurabi the Assyrian laid down an industrial code which aimed to solve the selfsame industrial problems we are wrestling with today; and in this code we find the relations between master and man carefully regulated and minimum wages fixed for all classes of artisans. The wage problem is the most difficult of all industrial problems because it bears directly upon the distribution of wealth, hence touches closely upon human nature with all its ambitions, hopes and fears. A satisfactory solution of this problem, which interests every living being, would no doubt usher in the millennium!

2. *Effect of industrial changes.*—It was inevitable that the industrial revolution should bring about

changed relations between master and man. In the old handicraft days, where the number of men employed was small and great accumulations of wealth had not separated the owner from the actual pursuit of industry, these relations were often very close and personal, savoring somewhat of the old patriarchal relations of centuries before. The apprentice was an integral part of the master's family and the mature workman a personal friend. Even after modern tools began to specialize men somewhat, a semblance of these relations remained and still remains, to a certain degree, where the number of men employed is very small.

As the size of factories increased and as the new methods became more effective, these simple and friendly relations began to disappear. Specialization and aggregation (see Section 3, Chapter III) tend constantly to divide men into classes and to separate them further and further from the employer. Except in small factories, the old friendly relations have been lost and to most employers labor has become a commodity to be purchased at the lowest market price. It is true, of course, that many employers are much interested in the welfare of their employes and are more anxious than ever to secure good workmen. But the problem of securing such help is, in general, delegated to others and the personal element is absent from the agreement which is based usually on business principles and the market rate.

3. *Effect on the worker.*—At the same time these influences tended constantly to cut off the workman from the ownership of either land or tools and to make him increasingly dependent on the employing class for an opportunity to earn his daily bread. The great advance in labor-saving machinery brought him face to face daily with degradation of labor (see Section 5, Chapter I) and observing the effects of these new methods, the worker very naturally set up such defences as he could against these influences that seemed to crowd him to the wall.

By gathering together many men with common interests specialization naturally tends to develop class consciousness and to encourage the natural tendency of all men to organize against common dangers. Labor unions, therefore, are a most natural result of our changed industrial methods. To try to legislate them out of existence is worse than foolish. They will persist so long as industrial methods make them possible or necessary, and they will disappear only with changes in our industrial methods.

4. *Net effects on the labor problem.*—As a net result of these industrial changes, the rewarding of labor is no longer a simple matter that can be settled personally, but is likely to be a matter of sharp bargaining between combinations of employers on the one hand and combinations of workmen on the other. The law of supply and demand has been rendered very sluggish in the labor market by the complexity of modern industry, and the conditions surrounding

the settlement of any labor controversy are usually very complex and confusing. Any hope of a satisfactory solution of any problem, industrial or otherwise, must rest upon finding the actual facts of the matter and in industrial disputes these are difficult to obtain.

Yet it is obvious that the continued struggle between organized labor on the one hand demanding all that it can get, and organized capital on the other hand banded together to oppose stubbornly the demands of labor, cannot continue indefinitely and cannot result in any satisfactory solution of the problem. And the trend of public opinion would lead to the belief that if these contending parties cannot reach some satisfactory agreement, public opinion thru legislation will enforce some kind of settlement of the trouble. Labor legislation, however, cannot be expected to solve the difficulty to the satisfaction even of the majority until more is known about the exact facts on which a settlement should rest. It may be doubted indeed whether there are any basic facts or principles on which all would agree as a basis of fixing wage standards. In all probability, the personal element will always play an important part in such matters.

5. *Importance to the employer.*—In industries employing large and expensive machinery labor costs are doubly important. So far as actual wages are concerned, it might make little difference whether a workman received $3.00 or $4.00 a day; but if the

difference in wages should be a measure of relative efficiency and if this difference is reflected manyfold in the product of a large and costly machine, the difference in output might be very great. It will not pay, therefore, to have inefficient men operating expensive machines where their inefficiency may be magnified in decreased production.

For the manufacturer who is hard pressed by competition there are, apparently, only two ways of reducing costs. One is by reducing wages, the other is by developing better methods. But low wages do not necessarily mean low costs, since labor is not as yet such a closely definable quantity as is material. In fact the latest philosophy of industrial administration tends to indicate that low labor costs and cheap output, far from being synonymous, may be diametrically opposed, and that low productive costs can often be obtained only by incurring high labor costs. At least, high labor costs and low productive costs are not necessarily antagonistic. A very comprehensive discussion of this question and of wage systems would exceed the limitations of this work, but enough will be included to show the general trend of this important phase of industrial life.

6. *Two primary methods of rewarding labor.*— There are two, and only two, primary methods of paying for work. One is to pay the workman for the amount of time which he spends on the work at an agreed rate for each unit of time. The other method is to pay the workman for the amount of work which

he produces at an agreed rate for each piece. The first method is called daywork, because formerly the most usual time unit paid for was one day. The second method is known as piecework, since payment is made by the piece. All other schemes for compensating labor are combinations of one kind or another of these two primary methods. These two principles and the difference between them should be carefully noted. Some of the more modern wage systems now in use have a complex appearance and would seem, at first sight, to rest upon deeper reasoning. Careful analysis will show, however, that in all cases these principles lie at their root.

Some of these new wage systems are sometimes spoken of as profit-sharing methods, which is an erroneous title. Money which is paid out as a direct compensation for service can in no way be classed as profit, which is properly defined as an undistributed balance after all costs have been paid. By similar reasoning no money divided as profit can properly be considered as wages of any sort. A later section will discuss certain profit-sharing schemes which aim to distribute part of the profits for a fixed period of time, usually a year, as a reward of faithfulness as well as for skill and industry. The term gain-sharing might, however, be fittingly applied to some of these new wage methods, for the element of gain sharing is sometimes a prominent feature of their operation. Basically, however, all of these methods rest, as has been noted, on the two principles stated above.

7. *Daywork.*—The term daywork, as has been seen, is a misnomer that has been handed down to us from the times when the day was the common unit for which wages were paid. Today, however, the unit of time for which pay is rendered may be the hour, the day, week, month or year. A better name for this method of pay would, therefore, be time work. In general, the higher the grade of the employe, the longer is the unit of time. Managers, treasurers, and other high officials, for instance, are usually hired by the year, or for a term of years, tho they are usually paid by the month. Engineers, foremen, and the like, are hired for and paid by the month. Other classes of labor are usually paid by the hour, usually no fraction less than one-half hour being considered. The philosophy of the system is well illustrated by this classification. As the unit of time bargained for becomes smaller, greater supervision, presumably, is required to insure that the employe gives the full service that is paid for. The presumption is that the men of higher rank will do this without so much supervision, since they have been selected with this end in view and because their more responsible position makes faithful service axiomatic.

The daywork method of rewarding labor is the older method and the reason for its original use can be easily seen. In the beginning of any industry the duties of the laborer are general and not special. The farm hand is still expected to do many widely different duties, each one occupying widely different

periods of time, and his hours of labor are still not definitely fixed as in factory work, but vary with the needs of the day. Domestic service, also, furnishes a very good example of daywork, little different in character from that prevailing in patriarchal days. The system was a most natural one under the older methods where the relation of employer and employe was quite personal and the employer depended on the loyalty of his workmen to obtain value received for the wages paid. Where the number of men is small and the work will permit of close personal supervision, this system is still effective. It is still in general use and will no doubt continue in use, even where other systems might be better, because of its simplicity. Where close supervision is not possible, as in directing work at a distance from the factory, day pay is usually the only workable method, but care must be exercised to select reliable men for such service.

8. *Advantages and defects of daywork.*—Daywork, therefore, is suited naturally to general work where the work itself and the duties of the worker are not clearly defined and where the supervision is close and personal. As factories became larger, workmen on day pay had great opportunities for "soldiering" or pretending to work while really doing less than they could. This was especially true when advanced types of machinery and tools were introduced, since, as has been explained in Section 6, Chapter IX, very little was known—or in fact is now known—as to the

productive possibilities of modern machines. This is not to be wondered at when the immediate effects of labor-saving machinery are considered. The workman, brought face to face with industrial changes that constantly threatened his economic independence, if indeed they did not threaten to wipe out his calling entirely, and instinctively feeling that he could influence the law of supply and demand in his favor, naturally did not work up to the limit of his capacity. The better class of workmen also found difficulty in securing recognition of their superior abilities as the number of men employed became larger; and these either became discouraged and lowered their production or they endeavored to raise the wage level of their entire class by organization. These tendencies were accelerated, no doubt, by the fact that in the beginning at least the lion's share of the profits flowing from the new methods went to the employer.

In isolated cases men may be driven by intimidation to exert themselves to greater efforts, but in general this is not so, and where any number of men are concerned, such efforts are invariably met with solid class resistance which tends also to lower the volume of production. No intelligent employer today depends on such methods to secure production, and every intelligent employer knows that a low average wage is synonymous with a low average in the volume of production. Day pay has, therefore, often proved to be not only inadequate but also unfair, both to employer and to employe under modern conditions.

9. *Piecework.*—Under piecework methods the worker is paid for the amount of work performed and not for the time he works. Thus the pay of a man on day pay who is earning $3.00 forging bolts, will not change, no matter how many or how few bolts he may turn out. But if he is paid at the rate of fifteen cents per bolt, he must make twenty bolts per day to earn his old wage of $3.00. If he makes more than twenty bolts, his pay rises accordingly and if he makes less than that number, his pay also falls in like proportion. If the piece rate is a fair one to both parties, this method would seem to be an ideal one for all concerned, provided the work is of such a character that piece rates can be set with intelligence. This method, apparently, restores to the ambitious worker the opportunity to secure the increased compensation due to him because of his superior qualifications and relieves the employer of all necessity of adopting driving methods. If piecework stimulates production, it lowers the cost and increases wages. Thus in the example quoted above, suppose the material cost of each bolt is five cents and that the cost of operating the machine (that is for power, heat, light, etc.,) is $4.00 per day. Then the cost per bolt when the output is twenty per day will be

$$\frac{(.15 \times 20) + \$4.00 + (.05 \times 20)}{20} = \$.40$$

When the output is 25 per day the workman's wages will be $3.75 per day and the unit cost will be 36 cents.

If, however, the production is dropped to 15 per day the worker's wages will be $2.25 and the unit cost will rise to 46⅔ cents.

It will be obvious that piecework is peculiarly adapted to cases where a large number of parts of one kind are to be made, and does not lend itself readily to the case where the parts are few and of different character. It can be applied to advantage, however, in the case of a single piece, provided the amount of work to be done upon the piece is sufficiently large to make intelligent estimates of performance worth while.

10. *Difficulties of piecework.*—The idea of piecework is, of course, very old. Under the handicraft system piecework was little used when workers were brought together in shops. It was extensively applied when work was done for others in the homes of the workers as in the textile industries. Here the piece wage was the natural system of payment, as the employer had not control of the worker's time. But with the isolation of the workers the peculiar problems of piecework did not arise.

In the main, factory industry inherited from the handicraft system day wages in shop work. When, however, the limitations of the day-pay method began to be obvious, employers naturally turned to piecework as a logical method of placing a part of the responsibility of production upon the worker and thereby reducing costs. The difficulty with piecework arose, however, from the lack of knowledge of

just what a fair piece rate should be. No systematic study had been made of the matter and under daywork there had been no easy method of determining just what the output of a good day's work should be with modern tools. When men were transferred from daywork to piecework, they easily made very large earnings, even when the piece rates were set initially to produce a higher output than under daywork.

To many employers it appeared that the increase in wages was out of proportion to the decrease in cost, and either because they really thought that the worker was getting more than his share of the returns or because of cupidity, they "cut" or reduced the piece rate so that the worker had to produce more to earn the same wage.

If the worker was not discouraged by the first cut, he often succeeded in again raising his wage to a high figure only to have the rate cut again; this performance being repeated, perhaps, several times until the worker found himself working much harder than formerly for a small advance in income. Piecework, has, as a consequence, come into bad repute with the working classes.

Piecework has also been opposed by the worker because of the risk which it involves. If all goes well with him and he makes a good day's pay, he is rewarded for his efforts; but when things go wrong, if the materials or work offer any special difficulties or if

his physical condition is not up to standard, he may fail to make a fair day's wage for reasons that are no fault of his own, and which would not affect his pay on daywork.

Labor unions have opposed piecework on ethical grounds, pointing out that it stimulates unrestricted competition between workmen—an evil that they claim, and justly, is too great already in our industrial system. They claim that as a result piecework tends to sow suspicion and distrust of each other and to destroy the brotherly feeling that should exist between fellow workers. Unquestionably there is much truth in this contention, and it would seem to follow that competition between workmen must produce the same result that it does between employers, where it certainly has not increased brotherly love. Piecework, therefore, may present difficulties, either because of lack of accurate knowledge or because of natural defects inherent in the method. The method has, however, been operated very successfully where great care has been taken to set accurate rates and where a cordial understanding has existed between employer and employe so that readjustments of the rate have been justifiable and have been made to the satisfaction of the worker.

11. *Contract systems.*—A modification or combination of the two pay systems discussed in the foregoing is in common use in shipyards, locomotive works and similar plants both in this country and in

Great Britain under the name of the contract system. In this system the employer makes a contract with a "gang boss" or subforeman to perform a given piece of work, which may require the services of many men of varying skill. Thus the contract may cover the building of a steel mast, the valve gear of a locomotive, or some similar enterprise. The gang boss furnishes all the men, paying them himself and making any agreement he may choose with them as to the method of pay, which may be day pay or piecework. The employer furnishes all the tools, equipment and material. To the employer, therefore, the plan appears as piecework; to the actual worker it may be daywork or piecework, while to the gang boss it may present several combinations.

The advantages to the employer are that he secures a definite cost on his product and, apparently, transfers the labor problem to the shoulders of the sub-contractor. On the other hand, the sub-contractor and his men have little or no interest in the equipment, and the cost of upkeep on tools under this method is proverbially excessive. The general principles of the method may also be questioned, viewed from the modern point of view of the relations that should exist between the real employer and his workmen. Obviously this method opens the door for sweat-shop methods which have proved to be such a curse in the clothing industry where the contract system has long had a firm hold.

REVIEW

How have modern methods of paying labor developed?

Why did the introduction of labor-saving machinery make inevitable the growth of labor unions?

What are the two primary methods of rewarding labor? Compare them.

CHAPTER XIII

REWARDING LABOR—NEW METHODS

1. *General.*—It was to be expected that the growth of the new manufacturing methods would bring forth new plans for rewarding labor, if for no other reason than that this growth presaged the disappearance of personal relations in large enterprises. The large operator of today is very unlikely to consider labor as a personal matter between the worker and himself, but to look upon labor as something to be purchased like any other commodity. Men speak of "buying labor" instead of "hiring men." This tendency is greatly to be deplored, for labor is essentially personal, and because of the personal relations involved it is difficult to measure it as one would measure material. It is small wonder, therefore, that under modern complex manufacturing conditions, with minute division of labor and the complex social and labor organizations resulting therefrom, these older methods of rewarding labor have been found to be inadequate. They are still, it is true, in general use and will continue in use wherever conditions are such as to render them satisfactory; but beyond doubt other methods are rapidly coming into use, particularly in the more complex situations.

2. *Halsey premium plan*.—The first effort of recent times, at least, to improve upon day and piecework is that evolved by Mr. F. A. Halsey and known as the Halsey premium plan. It now appears that similar methods had been in use in England many years ago; but while the idea may be old, Mr. Halsey is entitled to the credit of its introduction into modern factory work.

Under this method a standard time based upon previous experience is allowed for the work under consideration. For every hour that the workman can shorten this standard time he is paid a fraction of his hourly wage as a premium in addition to his regular pay. This fraction varies from one third to one half of the time saved. To illustrate, suppose a certain piece of work requires ten hours, normally, for its completion, and the workman's pay is $3.00 for ten hours. Suppose, further, that it is agreed that the workman shall receive one third of his hourly wage, extra, for every hour that he can shorten this standard time. Then the premium that he will earn if he does the work in nine hours will be $\frac{1 \times 30}{3} = 10$ cents and his earnings for the nine hours will be $(9 \times 30) + 10 = \$2.80$ or at the rate of $3.11 per day. Should he fail, however, to reduce the standard time or in fact should he exceed the ten hours set as a standard he would still receive $3.00 per day provided, of course, that he was not so slow as to be regarded an undesirable worker.

Or suppose that as in Chapter XII, Section 9, the worker is producing normally twenty bolts per day and that his wage is $3.00. If now under the stimulus of the premium plan he should produce twenty-five bolts per day, he would save one quarter of a day and his premium would be $\frac{1}{3} \times \frac{300}{4} = 25$ cents and his daily wage would be $3.25. The labor cost per bolt would fall from 15 cents to 13 cents. On the other hand, if he should fail to make twenty bolts per day his daily wage would still remain $3.00.

3. *Advantages and defects.*—The Halsey plan, therefore, recognizes the principle of increased pay for increased effort which is the basic principle of piecework, but the proportionate return for this increased effort is not so great as under the piecework plan. On the other hand this is compensated for by the protection which the worker enjoys against being penalized should he fail to attain the standard performance. The premium is easily computed so that each man can always know his earnings. No changes need be made in the regular routine of the shop in order to introduce this method and no workman is compelled to work for a premium unless he so desires. The conciliatory character of the Halsey plan has resulted in its introduction to a wider extent than any other gain-sharing method.

The plan is sometimes criticised because it does not give the worker the full benefit of his gain in production as is the case in piecework. To this it may be

replied that the employer is entitled to some of the gain because of the increased use and wear in equipment. But the best reason for this feature of the method lies in the fact that since the employer is receiving part of the gain he is less likely to cut the rate than in piecework. Another criticism is that the basic rates are set on the basis of experience with day pay or by the judgment of the foreman, and do not, as a general thing, represent what the worker can do when he really tries, so that it is easy for him to make large premiums, thus tempting the employer to cut the rate. Viewed from the standpoint of later pay systems there may be some truth in this criticism of the way the system has been applied. There is no inherent reason, however, why the basic rates for this system or for straight piece rate, may not be set by scientific time studies, so called. It is customary to set the standard performance in the Halsey method considerably higher than that made by a good day worker.

4. *The Rowan modification of the Halsey premium plan.*—The general principle of the Halsey method can be varied in a great many ways. One of the best known modifications of the plan is that due to Mr. James Rowan of Glasgow, Scotland. In the Rowan modification a percentage is added to the day rate, this premium being calculated by the following formula:

$$\text{Premium} = \text{Day rate for time consumed} \times \frac{\text{Time saved}}{\text{Standard time}}$$

To illustrate, using the same data as before, if the standard time is ten hours and the day rate $3.00, and if the workman can do the work in nine hours, his premium would be $\$2.70 \times \frac{1}{10} = .27$ and his pay for the job would be $\$2.70 + .27 = \$2.97$ or at the rate of $3.30 per day.

A peculiar feature of the Rowan plan is that the earnings of a workman can never exceed twice his normal daily wage. The controlling fraction $\frac{\text{Time saved}}{\text{Standard time}}$ constantly approaches unity as the amount of time saved increases; hence the bonus constantly approaches the day rate for time consumed. While this plan pays the worker liberally for the earlier gains in production, it makes it increasingly difficult to make higher gains. This naturally discourages the worker from trying to make a very high production and in this respect the plan differs from the original Halsey plan which places no limit on earnings. While there seems to be no logical reason for limiting output, the Rowan plan, no doubt, has a tendency to lessen the employer's desire to cut the rates because of excessive earnings. This is, however, a somewhat doubtful recommendation.

5. *Taylor differential piece rate.*—The standards of performance for the Halsey plan were based originally on such records of previous performances as were at hand, or in their absence upon the personal judgment of the foreman. In operating the pay sys-

tems discussed so far, little or no effort was made to find out, with any degree of accuracy, what constituted a fair basis for a day's work. The Halsey plan was a step in advance, in that it enlisted the worker's efforts toward greater output without penalizing him, as under piecework, should he fail to meet the established standard. It, therefore, opened up the way to a more intelligent discussion of the wage question, and there is no reason why later improvements cannot be applied to the Halsey plan.

In 1895, in a very remarkable paper read before the American Society of Mechanical Engineers, Mr. F. W. Taylor pointed out that it was possible by studying the details of any operation to determine a minimum time in which each detail operation could be performed and that on the basis of these details it was possible to fix the minimum time required for the job or for similar jobs. He pointed out, also, that by surrounding the worker with the best of conditions and with expert advisers, it is possible for the worker to attain the standards so set. The general methods of organization and procedure to secure these results, as advocated by Mr. Taylor, have been fully discussed in Chapters VIII and IX. It is important to note, however, that Mr. Taylor's methods and those that have grown out of his experiments involve much more than a change in plans for rewarding labor, as they also involve radical changes in shop management, the system of payment being devised to en-

courage the worker to attain a result that had been carefully predicted and which it was known he could reach.

To this end Mr. Taylor introduced what he called a differential piece rate system involving a high piece price when the standard was reached and exceeded, and a low piece price when the standard was not reached. Under this method there is every incentive toward maximum production, particularly as there is a penalization if the standard is not reached. This penalization is greater than exists under straight piecework, as the lower piece rate is set purposely low to spur the worker to greater effort. It is like straight piecework in that the worker is not assured of his day's wage should he fail to reach the required standard of production.

6. *Comparison with older methods.*—There is no new principle involved in Mr. Taylor's piece rate method and it was not uncommon long before he presented his paper to make rough time studies of operations. The idea of making minute and accurate time studies was new and has opened up large possibilities in the matter of predicting the time of operations in advance and of setting the wages accordingly. In comparing these wage methods with those that preceded them, it should be remembered that the cost of determining just how long it should take to do a piece of work may be considerable. The cost of surrounding the workman with the best of conditions and with expert advisers may also be great, so that a large out-

put must be secured, as compared with the output under older methods, to make a margin of profit.

Under the Taylor method of expert analysis and preparation, the industrious worker probably has a greater chance of reaching his greatest productive capacity than under the older methods where he depended solely upon his own initiative and ingenuity. The Taylor system really pays the worker as much or more for his cooperation as it does for his skill in devising economic means for producing the work, and is therefore open to the criticism that it tends to kill initiative and resourcefulness on the part of the worker. This criticism, however, holds for all labor-saving machinery and for all labor-saving management. All such influences tend to separate the mental labor of planning from the manual work of performing, placing the planning in the hands of the more able men.

7. *Labor displacement.*—A more serious criticism which demands careful weighing is that the ability to measure with certainty a workman's capacity places in the hands of the employer a power which may be used to the injury of the working classes. It is contended that the ability to predict performance and to set wages accordingly gives the employer the power to exclude from the industry all but the very best men. This is true of the individual employer, and a temporary displacement of labor with its attendant hardships for the worker appears to be one of the inevitable growing pains of industry. But it is too

hasty a generalization to argue from the particular case to the whole industry. The fear exaggerates the power of the employer to do as he pleases. It forgets that his success depends on holding his market, and that he is quite as much interested in extending his market and employing the labor necessary to do this as he is in saving labor costs on the individual workman. None the less, this fear has even dictated Federal legislation, forbidding the use of these methods in government establishments. But is there any logical reason why an employer should be prevented from finding out just what value he is buying?

It is of course true that savings in labor, whether thru improved methods of work or thru labor saving machinery tend to displace a certain number of workers, provided there is no increase in the demand for the product on which they are engaged. Experience has, however, amply demonstrated that these effects are neither instantaneous nor far reaching because of compensating influences. In the first place the transition from one industrial method to another and the consequent displacement of labor is gradual, not sudden. It reaches the several factories of an industry one by one, not all at once. In the meantime demand is likely to expand, and the ultimate result is not to produce the same product with less labor but a greater product with the same labor.

The unemployment of workers, even for a time, is an evil which is to be deplored, but it would be a still greater evil if the general welfare of the community

was to be kept on lower levels and economic progress was to be halted to avoid the temporary suffering of the few.

8. *The Gantt bonus plan.*—While the Taylor differential piece rate was developed in close connection with the system of industrial management which has become identified with Taylor's name, it has not been used to any great extent either with the Taylor system or elsewhere. This is due no doubt to the penalizing effect which has been noted. The penalizing feature makes this wage system difficult to introduce because of fear on the part of the workman that he cannot attain the required standard and thus, aside from his lowered earnings, will be in danger of ultimate dismissal. Mr. H. L. Gantt, who was closely associated with Mr. Taylor in his pioneer work and who has had every wide experience in applying Taylor's methods, has introduced a plan of remuneration that removes these difficulties while holding out a good reward for extra effort. Under the Gantt plan the workman is assured of his day's pay as under the Halsey plan. A careful study is made of the work and of the surrounding conditions, as in the Taylor plan, to determine just what a good performance should be; and a definite task is assigned to the worker on the basis of this analysis. If the worker equals or exceeds this standard performance, he is given a bonus in the form of an extra time allowance. Mr. Gantt has called his plan the "task and bonus" plan, and this name has become associated with this method.

To illustrate this method, suppose that under the carefully prepared conditions the worker can be expected to produce 40 bolts per day instead of 20 as in the older methods, the day rate being $3.00 as before. The time allowed for each bolt would therefore be $\frac{10}{40} = .25$ hours. Suppose further that the bonus is set at 33⅓ per cent of the time allowed. If the worker makes just 40 bolts per day, he earns a bonus and is given credit for $(10 + \frac{10}{3}) = 13.33$ hours, which at thirty cents per hour is $4.00 per day. Should he fail to make 40 bolts, he would fail also to earn a bonus, and his pay would be $3.00 per day. Should the worker exceed the task and make, say, 50 bolts, he would be credited with the time allowed for 50 bolts plus a premium of one third of that time. Thus the time allowed for 50 bolts would be $50 \times .25 = 12.5$ hours and the premium would be $\frac{12.5}{3} = 4.16\frac{2}{3}$ hours. The worker's daily earnings would therefore be $(12.50 + 4.16\frac{2}{3}) \times 30 = \$5.00$. It will be noted that the rate per piece is just the same when the task is just performed as it is when 50 bolts are made, namely, ten cents per piece. That is, the Gantt plan gives day pay when the task is not accomplished and piecework pay when the task is completed or exceeded.

9. *Comparison with other methods.*—The Gantt plan, therefore, embodies the conciliatory features of the Halsey plan while including the analytical fea-

tures of the Taylor method of administration. The task must necessarily be set high, as the output must be large in order to pay for the extra work of preparation and also to obtain a margin of profit. In this connection Mr. Gantt in his own work has laid great stress on the necessity of training men, not only in meeting the conditions necessary to earn a bonus, but also in good industrial habits such as regularity. He thus tries to utilize labor as he finds it, and instead of excluding the poor or mediocre man, he endeavors to develop him into a bonus earner. Mr. Gantt has also applied the plan to the work of the foreman, making him the recipient of a bonus when a given number of men under him earn a bonus. This is not only an incentive to the foreman to keep the conditions surrounding the workmen up to standard, but also encourages him to teach them as much as he can concerning the work. The general idea, no doubt, has much merit and Mr. Gantt has had considerable success in operating it. Like the Taylor system it has been criticised as dividing the workmen into two classes, namely those who can earn a bonus and those who cannot earn one—a division which may lead to heart-burning. It is an open question, however, whether this feature is any more marked under this system than in any other where remuneration is based upon individual effort. Such differences will always appear so long as we are working under a competitive system, and at present there is little possibility of any

marked departure from this basic feature of modern industry.

10. *The Emerson efficiency plan.*—Another interesting wage method is that introduced by Mr. Harrington Emerson, a well-known exponent of efficiency methods. The Emerson plan, while seeking to attain the same results as other modern systems, proceeds along somewhat different lines. Under this method the worker is assured of his fixed daily wage, as in the Halsey system. As in the Taylor and Gantt systems, a careful study is made of all of the details of production and a standard performance is established which represents a fair task for the worker. If the worker attains this standard performance, he is given a large bonus, as in the Gantt system, but smaller bonuses may be earned, even tho the standard performance is not attained, very much as in the case of the Halsey premium plan.

To illustrate, let it be supposed that a certain job has a standard time of 60 hours set upon it. If now the worker performs the work in 60 hours, his efficiency is said to be 100 per cent. If he takes 120 hours to do the work, his efficiency is rated at 50 per cent. If he should take 50 hours to do the work, his efficiency is said to be 120 per cent. The workman must make an efficiency of at least 66⅔ per cent before he receives any bonus. The following table gives the bonus per dollar of wages as recommended by Mr. Emerson. From this it will be seen that the initial bonus at 66⅔ per cent is very small, rising very slowly

at first, as the worker increases his efficiency, and then rising more rapidly until at 100 per cent efficiency the bonus is 20 per cent. For efficiencies above 100 per cent still higher bonuses are paid, tho it should be remembered that it is the expectation in the Taylor, Gantt and Emerson plans to make such a careful study of the work and to set the task so high that the standard is difficult to attain and very high bonuses unlikely.

EMERSON BONUS RATES

Efficiency per cent	Bonus per $1.00 wages	Efficiency per cent	Bonus per $1.00 wages	Efficiency per cent	Bonus per $1.00 wages	Efficiency per cent	Bonus per $1.00 wages
67	0.0001	78	0.0238	88	0.0832	99	0.1881
68	0.0004	79	0.0280	89	0.0911	100	0.20
69	0.0011	80	0.0327	90	0.0991	101	0.21
70	0.0022	81	0.0378	91	0.1074	102	0.22
71	0.0037	82	0.0433	92	0.1162	103	0.23
72	0.0055	83	0.0492	93	0.1256	105	0.25
73	0.0076	84	0.0553	94	0.1352	110	0.30
74	0.0102	85	0.0617	95	0.1453	120	0.40
75	0.0131	86	0.0684	96	0.1557	130	0.50
76	0.0164	87	0.0756	97	0.1662	135	0.55
77	0.0199	87.5	0.0794	98	0.1770	140	0.60

11. *Practical operation of Emerson plan.*—Mr. Emerson, in the actual operation of this method, recommends the practice of calculating the bonus by the month rather than by individual jobs. To illustrate, suppose that a workman whose wages are $.30 per hour works for 260 hours during a given month, performing in that time tasks the total standard times of which have been set at 234 hours. His efficiency would be $\frac{234}{260} = 90$ per cent. His wages would be $78

and his bonus for the month would be 78 x .0991 = $7.73. His total earnings for the month would, therefore, be $78 + $7.73 = $85.73. The advantage claimed for this method of calculation is that it tends to encourage the worker to make a bonus on every task since the averaging into his monthly work of a number of poor performances may destroy the possibility of earning a large monthly bonus. This penalizing feature is offset to a large degree by the fact that it is comparatively easy to earn some bonus. The plan in fact is much less selective, so far as the worker is concerned, than either the Taylor or Gantt methods, and is much more conciliatory and hence perhaps easier of introduction.

REVIEW

What is the principle underlying the Halsey Premium Plan for rewarding labor? Show how this works to the employe's advantage.

What variation of the above plan is made in the Rowan system of paying for labor?

How does the Taylor differential piece rate tend to bring about maximum production? Is it wise to attach a penalty to substandard work?

How does the Gantt bonus plan tend to overcome the objection to the Taylor plan?

What principle did Emerson have in mind when he prepared his efficiency plan for rewarding labor?

CHAPTER XIV

COMPARISON OF WAGE SYSTEMS—PROFIT SHARING

1. *Comparisons general, not exact.*—It will be clear from the foregoing that it is exceedingly difficult, if not impossible, to make accurate comparisons between these several wage methods, not only because they differ so widely in the philosophy on which they are founded, but also because of the widely differing features involved in their application. Any comparisons in terms of numbers, therefore, must be construed as being merely suggestive and in no sense conclusive. Such comparisons, however, may serve to show more clearly the relative importance of certain features as viewed by employer and employe, even tho the assumptions on which they rest are not absolutely accurate.

2. *Comparison of costs.*—Let it be assumed then that the worker under good day-pay conditions is producing 15 bolts per day and is receiving $3.00 per day. Suppose also that the cost of operating the machine, i. e., for power, light, etc., is $4.00 per day and that the cost of the material in each bolt is five cents. Let it be assumed also that when the worker

is put on piecework, he is paid 15 cents per bolt and that when he is working under the Halsey premium, he is expected to produce 20 bolts per day before receiving a premium, this premium being one third of the time saved. Under the Rowan plan the 20 bolts in a standard day of 10 hours is made the basis for figuring the premium. Assume that under the Taylor differential piece rate the highest price is 15 cents per bolt and that 10 cents is the lowest rate.

Suppose again that under the Taylor, Gantt and Emerson systems of payment he is expected to produce 30 bolts per day before receiving a premium; that under the Gantt system the bonus is 33⅓ per cent, and that under the Emerson plan his premium is set according to the table in Chapter XIII, Section 10. Let it be assumed further that the cost of operating the machine under these three advanced methods is raised to $5.00 per day because of the preparation and supervision involved. Then the cost per bolt for varying production and under the several methods is as given in the following table.

COMPARISON OF UNIT COSTS UNDER DIFFERENT WAGE SYSTEMS

Wage System	Cost per bolt in cents for varying production					
	10 bolts	15 bolts	20 bolts	25 bolts	30 bolts	40 bolts
Day pay	75	51⅔	40	33	28⅓	22½
Piecework	60	46⅔	40	36	33⅓	30
Halsey premium	75	51⅔	40	34	30	25
Rowan premium	75	51⅔	40	35⅔	31⅔	26¼
Taylor differential piece	65	48⅓	40	35	36⅔	32½
Gantt task and bonus	85	58⅓	45	37	35	30¾
Emerson efficiency	85	58⅓	45	37⅔	33⅔	29

3. *Deductions.*—An examination of this table will show that the unit cost is less under daywork as the production increases than under any other method. This is logical, since the worker's pay is not increased, and if, therefore, the greater production can be obtained under daywork, that is the cheapest way of obtaining it. It will be noted, furthermore, that the unit cost is greater under straight piecework for increased production than under any other method except in a few instances under the advanced methods. Straight piecework is obviously an expensive method of remuneration, since the worker obtains full benefit in pay due to increased production. But it is clear, also, that there are limitations to the amount of money one can spend in preparation and supervision and still keep the unit cost down below that of the older pay systems. In making comparisons of these unit costs it should be remembered that probably not more than 15 bolts will be produced under day pay and not more than 20 or 25, at most, under piecework and the Halsey plan; while under the Taylor, Gantt and Emerson systems there is a presumption that the production will rise to 30 per day. In fact if it does not rise to this amount, the new methods would have little or no advantage over the old methods. There is, however, an indirect gain due to increased production even tho the unit cost is not decreased, because of the fact that other elements of the total unit cost are lessened by such an increase. This phase of the matter is fully discussed in the volume on "Cost Finding."

4. *Comparison of wages.*—The employer, who is naturally concerned with unit costs, will be most interested in those aspects of wage methods that have just been presented. The worker, however, is interested in other aspects of these methods. The following table gives the earnings of the workman for the same conditions and output as were used to compute the foregoing table on unit costs.

COMPARISON OF EARNINGS UNDER DIFFERENT WAGE SYSTEMS

Wage System	Workman's earnings in dollars for varying production					
	10 bolts	15 bolts	20 bolts	25 bolts	30 bolts	40 bolts
Day pay	3.00	3.00	3.00	3.00	3.00	3.00
Piecework	1.50	2.25	3.00	3.75	4.20	6.00
Halsey premium	3.00	3.00	3.00	3.25	3.50	4.00
Rowan premium	3.00	3.00	3.00	3.60	4.00	4.50
Taylor differential piece	1.00	1.50	2.00	2.50	4.50	6.00
Gantt task and bonus	3.00	3.00	3.00	3.00	4.00	5.33
Emerson efficiency	3.00	3.00	3.00	3.15	3.60	4.62

While, as has been noted, these figures are suggestive only, they give an idea of the relative merits of the several methods of pay. It will appear that daywork in general gives the worker the smallest reward, tho in return it protects him against loss should he fail to do even a fair day's work. Piecework on the other hand promises the greatest reward, but this is offset to some degree by the penalizing effect of piecework under low production. This effect is very marked, it will be noted, in the Taylor differential piece rate method. The earnings under the more advanced methods, where the worker is assured his day

pay, lie for the most part between piece- and day-work, as would be expected, since money must be expended to plan and supervise these higher productions. In the data chosen, the upper piece rate of the Taylor differential system is probably placed somewhat high in relation to the other factors. It should be remembered, also, in making comparisons that the worker's chances of attaining a high wage are greater under the advanced methods than under the older methods which are based upon fixed day rate or upon the worker's initiative.

5. *Conflicting interests.*—In making comparisons of the relative merits of these wage systems, it should be borne in mind that the interests of the employer and of the employe are not always the same. The employer, pressed hard by competition, naturally wishes to buy labor as cheaply as he can, while the worker, pressed hard by a desire to better his conditions, desires to sell his skill and knowledge at the highest price. The manufacturer naturally desires large output, especially when the margin of profit is small; the worker is, in general, not interested in increasing his output unless he receives increased compensation for so doing. In fact he may be strongly opposed to increasing his output on the general theory that increased output means cheaper goods and consequently lower wages. To reconcile these conflicting views is no easy matter, especially when it is realized that under modern conditions, where large numbers of men are employed, it is difficult if not impossible

to make a very strong appeal to the worker's sense of loyalty to the employer's interests. Any appeal to the worker to increase his output must, in general, be accompanied with some assurance of increased remuneration.

Mr. Taylor found in his own experience that in order to induce common laborers to put forth their best efforts it was necessary to pay them from 30 to 60 per cent more than the average for that class of labor. He found that it was necessary to pay skilled mechanics from 70 to 80 per cent more than the average for that class, and that for work requiring a high degree of skill or intelligence, close application and physical effort it was necessary to pay as high as 100 per cent more than the average to obtain the highest output.

Mr. Taylor's statements are undoubtedly true. The fact that increased production eventually benefits the entire working class has little influence on the worker toward increasing his efforts. He demands as high a wage as he can get, because his immediate needs are much more important to him than prospective advantages to his posterity, since such gains are vague, distant and uncertain.

6. *The appeal of the new wage systems.*—These new wage systems, therefore, recognizing these inherent difficulties, make an appeal to the worker to increase his effort and to receive increased pay immediately. This point of view is radically different from the appeal of day pay which holds out increased

pay only as a result of long and well-tried service. Whether these new methods are here to stay or not they have demonstrated that high pay and low unit costs, far from being irreconcilable, are obtainable at one and the same time. The tables of unit costs and daily earnings just given are sufficient proof of this statement which has also been amply proved in practice. These tables also show clearly that there is no truth in the opinion so widely held that cheap labor will produce low unit costs. Cheap labor, in general, means low output and high unit costs. This is true even in the case of day pay. No thoughtful manager would expect great results from a cheap superintendent. The reasoning back of this decision applies equally to the average worker. Mr. Gantt's theory that it pays to teach men and encourage them to greater effort thru added pay is logical and sound.

7. *Modern tendencies.*—It will be evident upon reflection that the wage systems that have been discussed are capable of infinite variation. It is evident also that the pay system that will apply to one shop may be totally unfitted to the conditions existing in another, since in general every shop is a problem by itself. There is really no reason why any manager cannot take the ideas conveyed by these methods and build up a system of his own that will be suited to his peculiar problems. It really makes little difference what the details of a pay system are, so long as it is fair to the employer, insuring him full return for his expenditures, and just to the employe by rewarding

him fully for his labors. Certain features of these new methods, however, deserve more than passing notice.

The Halsey premium plan was the first recognition thru a pay system that the old methods whereby the worker was coerced into greater effort by slave-driving were passing away in favor of more intelligent and more equitable methods. It is true that under piecework the driving was not so apparent and the worker was apparently upon his own responsibility; yet, as has been shown, piecework can—and only too often it did—result in the worst kind of driving thru repeated rate-cutting. The new methods frankly recognize the principle of increased pay for increased effort. This principle would seem to be eminently fair to all concerned.

8. *Rights of the employer.*—But while the modern employer may readily admit the fairness of this principle, he also may insist on his own right to find out, if possible, what constitutes a fair day's work and to pay accordingly. There can be no logical objection to this demand and the employer is clearly within his rights when he uses time study and motion study to find out what he is paying for. There can be no logical objection raised to any preparation or planning of processes that he may see fit to make, which will in any way expedite the work, any more than a logical objection can be raised against the introduction of a labor-saving machine.

If, however, the employer should attempt to use

these new measuring devices as a means of eliminating from his shop, or in a broader way from an entire industry, all that fall below a given standard, he would surely open up a serious problem. Such an attempt would surely run counter to public opinion; and public opinion tends constantly to limit our personal rights and privileges so far as we are employers or employes.

It is the fear of something of this kind which makes the worker oppose some of these new methods. Piecework and the Halsey system involve little or no change in machines, processes or management, other than those that come from the worker's initiative, and his status as a worker is not changed. The Taylor, Gantt and Emerson wage systems, however, are closely connected with the introduction of planning departments, functional foremanship and other features of advanced management which are all founded on a considerable extension of the principle of division of labor. This movement forecasts a further disintegration of all trades affected and a rearrangement of the functions of all workers concerned. Now changes of this kind, whether brought about by the introduction of labor-saving machinery or by the introduction of labor-saving management, bring with them the spectre of degradation of labor. (See Chapter I, Section 5.) It is not surprising, therefore, that labor, organized and unorganized, is often found opposing these new pay systems and the changes connected with them. Workers feel safer under the old pay system, and any of these newer

methods must be introduced with caution and only after the confidence of labor has been secured.

9. *Resumé.*—In contemplating these wage systems it should be remembered that their greatest importance to students of industrial methods is to indicate the difficulties of the wage problem, and in no sense can they be accepted as final solutions of this problem. A comparatively few years ago all industry was conducted on a handicraft basis; the relations of the employer to the employe were of a paternal character, and the question of wages was settled as a personal matter between them. We have in an amazingly short time built up an industrial system that is fiercely competitive. The employer found that he must bid, and bid closely, to secure work for his enterprise. Quite naturally he found it necessary to look more closely at the returns he was obtaining from his workmen for the wages expended. Failing to secure by personal persuasion or by driving methods the results he felt were essential to the life of his enterprise, he tried to fix piece rates, thus doing away with all personal relations and establishing the same relations between him and the worker as exist between him and the parties from whom he had secured his contracts. Had he possessed accurate knowledge of what these piece rates should be, the history of piece rate work might have been different. Rate fixing by foremen and by others who had made more or less of a study of this problem has been in times past most notoriously inaccurate, until today most workers distrust rate

setting that involves methods or processes with which they are not familiar. Piecework has, therefore, been generally opposed by the worker—particularly by organized labor.

The Halsey premium plan undertook to break this deadlock by accepting the prevailing wages as a basis and by adding thereto a bonus for extra effort. The conciliatory character of this plan, as has been noted, has caused it to come into considerable use. It should be noted that up to this time practically all responsibility for production was laid upon the worker himself, the foreman even, in most cases, being of little direct help in promoting more efficient ways and means of doing the work.

The Taylor system and those that have grown out of this method proceed on a radically different theory. Here the work is carefully planned in detail and in advance of production. It is claimed by the advocates of these systems that before work is begun it is known quite accurately how long each detail operation will take. Considerable doubt has been expressed by many as to the accuracy with which the time of performance of work can be predicted, but unquestionably these new methods of time and motion study have cleared away much of the ignorance and uncertainty as to what constitutes a fair day's work. At least they have indicated very clearly that such information is obtainable and have shown the methods by which it can be obtained. Granting, however, that these methods are quite accurate, and granting that

it is possible to predict what constitutes a fair day's work, there still remains the problem of what constitutes a fair day's pay, which is quite another matter. The great problem back of all this discussion is the manner in which the profits of industry shall be divided between labor and capital. Rightly or wrongly, a large proportion of the working class feel that the division, as made at present, is not equitable and they are much more concerned with the basis or basic rates on which wages are fixed than with the particular formula or method by which the gradations are computed. A discussion of this hoary problem lies outside the scope of this book, but it will be clear to any student of industry that a solution of this, the greatest of industrial problems, lies deeper than the usual discussion of the relative merits of the details of wage systems. It may be well in closing this chapter to discuss briefly some of the attempts that have been made along other lines to solve the wage problem.

10. *Profit sharing.*—A number of attempts have been made to solve this vexing problem by distributing to the workers a share of the profits in addition to their regular wage. On the face of it this scheme would appear to promise a satisfactory solution, provided the division of profits could be made satisfactory to all concerned. The practical operation of such schemes, however, is beset with difficulty. Usually the division of profits is made among those of the employes who have been with the concern a certain fixed

time and the distribution is made semi-annually or annually.

While at first sight profit sharing may seem to be a reasonable solution of the difficulty, it should be remembered that the conditions that fix the profits are controlled to a very small degree by the worker, and that any extra effort which he may put forth may be more than offset by foolish or extravagant methods, poor business judgment or adverse industrial conditions with which he has little or nothing to do. A reward of this kind is, therefore, speculative and remote; and if it does not materialize, the worker is bitterly disappointed. Any division of profits made under modern methods of industrial organization must savor more or less of gratuity. This is particularly true since, for the most part, employers are not willing to open their books frankly to the employes, who therefore have no way of knowing whether the promise, if one has been made, has been carried out in good faith. Dissatisfaction is likely to result. Workmen are always willing to share the gains of industry, but are not willing, nor as a rule are they able, to share any losses that may be incurred. There is no reason, furthermore, why they should share in losses, since under modern methods these matters are in a large degree beyond their control.

It should be carefully noted also that profit sharing differs radically from the wage systems that have been discussed. Under any wage system the daily wage and extra reward, if any, is paid at once and

paid to the individual in proportion to his diligence or skill. The reward of profit sharing, however, comes at intervals and, like the rain, falls upon both the just and the unjust, rewarding the lazy as well as the diligent. The diligent and skillful worker naturally resents such lack of discrimination, hence profit sharing, when practiced in this manner, must tend to kill personal initiative and to reduce all productive effort to mediocrity.

A variation of profit sharing consists in making provision for the worker to invest in the capital stock of the company. While, perhaps, there may be some virtue in making such provision for the officials of the company, there are limitations to the application of this principle to the rank and file of the workers. There is little or no connection between a worker's capacity to earn money and his ability to invest it. The ablest and most highly paid worker may have family ties or financial misfortunes that debar him absolutely from the privilege of buying stock in the concern; while the laziest or most incompetent man, because of different conditions, may easily make such an investment.

11. *Further variations of profit sharing.*—Like all systems of remuneration, profit sharing permits of endless variation. One of the most interesting attempts along this line is that of Mr. Henry Ford who pays an exceptionally high wage to those who comply with certain standards of living, these standards covering moral attainments, ability to save, and other

personal qualifications that are only indirectly connected with the work of the factory. While this plan is often referred to as a profit-sharing scheme, in reality this is incorrect. The extra reward which the worker receives is not proportional in any way to the profits of the business, nor to the effort that the worker may make as an individual to increase these profits. It is questionable, indeed, whether such methods make for the permanent benefit of the working class. It is to be hoped that eventually the worker will stand on his own feet, a self supporting industrial unit, receiving what is his just due because he has earned it, and receiving enough compensation to enable him to live in accordance with modern ideals.

12. *Cooperative systems.*—Many able men who have studied the industrial problems have turned to cooperative ownership as a solution of the difficulties involved. Many comprehensive efforts have been made thus to restore to the worker the ownership of his tools of production which the industrial revolution wrested from him. A few of these attempts have met with some measure of success, but for the most part they have resulted in failure. In this connection it should be noted that there is a great difference between cooperative ownership of property and cooperative administration of it. Most of our large enterprises are owned cooperatively by the stockholders thru corporation organization, and it is possible for large bodies of people thus to own and in a general way direct the policies of the enterprise.

But experience has shown that the administration of such policies must be placed in the hands of a limited number, and that this limited number must be remunerated in proportion to the responsibility assumed. We know of no instance where large bodies of men have operated complex industrial enterprises by popular control, each man sharing equally the gains and losses of the venture. It is doubtful, indeed, if we shall ever see such an enterprise. The demands of industry are exceedingly varied, men come into the world with widely varying degrees of ability, and society in general has had to pay in proportion to services rendered. Cooperative ownership is a possibility, but cooperative administration is as yet a utopian dream.

REVIEW

Why is the piecework system of pay generally opposed by organized labor?

Demonstrate by using any of the newer systems of paying labor that high pay and low unit costs are reconcilable and that cheap labor usually produces high unit costs.

Has any employer the right to retain only those workers who attain a definite standard for a day's labor?

What systems of profit sharing have been tried by employers who are seeking to settle the question of a fair reward to labor?

CHAPTER XV

STATISTICAL RECORDS AND REPORTS

1. *Need of statistics.*—It was shown in Chapter V that in a well-regulated enterprise all details of operations are carefully recorded and reported to the administrative office. These returns for the most part have to do with labor and material and for that reason most of them go first to the cost department and form the basis of wage payments and cost records. When they have served their purpose in this manner, these returns are still of great value in making up condensed statements or reports of the activities of the business, so that the manager may be kept fully informed regarding all important tendencies. Other returns, such as the results of tests of products, records of shipments, records of sales and many other returns which show the results of the activities of the enterprise, also flow in from other sources. One of the problems of management is so to arrange these many and varied detail statements that a clear view can be obtained at very frequent intervals as to the state of the business.

In an industrial enterprise of any considerable magnitude it is impossible for the manager to keep under his immediate and personal control much more

than the general direction of the business. He must delegate responsibility and authority to those directly under him, and these, in turn, must still further intrust responsibility and authority to those under their direction and so on down thru the entire organization.

As an enterprise grows, the duties of the higher officials come to be more and more of a supervisory nature, and details must be trusted more and more to subordinates. But as the business grows, it also becomes more difficult for those in authority to see by observation alone exactly what is taking place, while, at the same time, it becomes increasingly important and necessary that they have a clear conception of these matters if they are to guide the enterprise successfully. Some one has said that the secret of success in management is to organize, deputize and supervise the activities of the enterprise; and in a rough way this expresses the general principles involved. If the manager cannot personally observe what is happening under him, he must, at least, organize his methods in such a way that all tendencies and indicative results will be brought before him in a clear light.

2. *Financial statement.*—Since commercial success is measured in money, it is natural for the manager to look for such financial statements as will throw light on his problems and he naturally turns to his general accounting books for such help as they may give. In so far as general results are concerned, these

accounts are helpful and the balance sheet and profit and loss account, containing as they do a summary of what has occurred in financial form, are very helpful in problems of management. But these statements are given to him only at long intervals, while his daily problems of management demand up-to-date information regarding many details of the business that do not appear separately in the general account, but which may be found in the returns to the cost keeper or to some administrative official. From what has already been said, it will be evident that the manager cannot find this information himself; but if he knows in general what is desired and the form in which it is best to present the matter, it is comparatively easy for the officers of departments that receive returns to recast the information thus received into condensed reports that will automatically and regularly supply the manager with the information that he desires.

3. *Value of reports.*—This broader conception of the use of returns as a means of measuring and controlling industrial activities is not very generally appreciated. A system of carefully selected reports is the only method by which a manager can form an intelligent estimate of the controllable and uncontrollable factors of his business; it is also the best way by which to find the need of betterments and to direct their enforcement intelligently. The number and character of the reports which a manager may consider necessary will, of course, differ with the industry. As has been noted, also, they may come from

several sources. It may be well to note, however, that the greatest source of such reports is the cost department; in fact, a good cost system is absolutely essential in obtaining most of the important managerial reports of a manufacturing enterprise. The profit and loss statement, for instance, can be made up annually or semi-annually, or at other times when an inventory is taken with no reference to a cost system. But if it is desired to make up a monthly statement as shown in Figure 15, it is obvious that some means must be at hand for evaluating quickly and accurately such items as material on hand, work in process and finished product. Such means are provided only by a good cost system.

4. *The monthly statement.*—Of the reports that come before the manager none is more important than the monthly statement. Figure 15 shows a typical monthly statement of the affairs of a manufacturing company. Such a statement shows in a concise manner the status of all the important activities of the business in a classified form. The total values of all assets and liabilities are noted as are also the values of surplus and profits. Usually the corresponding items are given for the previous month and the manager can see at a glance just what changes have taken place in his assets and liabilities and also in other matters not directly connected with the manufacturing department. All details are omitted, yet such a statement shows very clearly whither the business is tending, what matters need

MONTHLY STATEMENT, BROWN MFG. CO.

	MARCH 31, 1916						APRIL 30, 1916					
	DR.			CR.			DR.			CR.		
PERMANENT ASSETS												
REAL ESTATE	60	500	00									
BUILDINGS	200	225	00									
MACHINERY AND TOOLS	150	345	00									
FACTORY FURNITURE	7	240	00									
OFFICE FURNITURE	2	100	00									
DRAWINGS AND PATTERNS		100	00									
TOTAL	420	510	00									
CURRENT ASSETS												
CASH	7	241	52									
STOCKS AND BONDS	2	500	00									
NOTES RECEIVABLE	1	250	50									
ACCOUNTS RECEIVABLE	75	240	30									
RAW MATERIALS	40	264	18									
MATERIAL IN PROCESS	50	146	15									
FINISHED PRODUCT	20	240	24									
GOODS ON CONSIGNMENT OUTWARD	5	140	10									
DEFERRED CHARGES	1	240	00									
TOTAL	203	262	99									
PERMANENT LIABILITIES												
FUNDED DEBTS												
MORTGAGE BONDS				10	000	00						
MORTGAGES				5	000	00						
TOTAL				15	000	00						
CURRENT LIABILITIES												
NOTES PAYABLE				35	000	00						
ACCOUNTS PAYABLE				52	246	15						
PAYROLL				3	218	16						
TAXES ACCRUED				1	240	12						
INTEREST ACCRUED					400	20						
RESERVES				1	240	14						
TOTAL				93	344	77						
NET WORTH												
CAPITAL STOCK												
COMMON				375	000	00						
PREFERRED				100	000	00						
SURPLUS AT FIRST OF YEAR				21	245	16						
NET PROFIT TO DATE				19	183	06						
TOTAL				515	428	22						
GRAND TOTAL	623	772	99	623	772	99						

FIGURE 15

looking after and what activities are going well. Some of the items that appear on the monthly statement come, as has been noted, from the cost accounts, but the majority of them are found in the general accounts.

5. *Departmental reports.*—Aside from the financial and similar reports that grow naturally out of the general accounts it may be good policy to call for special reports from departments or such other activities as will best serve to indicate the trend of the business. The sales department, for instance, should make a periodic report showing the amount and character of sales and similar information. It should also send in special reports bearing on any movement in the field that will be useful in manufacturing. Thus competitors' prices or descriptions of new apparatus, put on the market by competitors, is helpful to the designing and manufacturing departments. From the stores department the manager should receive a report of product on hand; and with this and a manufacturing report of the orders in process he can intelligently place new shop orders. The cost department should furnish him monthly with a report on the costs of all product that has been completed. This report may give the totals of labor, material and expense that have gone into the several products, and by comparison with sales prices the manager can see what lines or special machines are profitable or otherwise. Other departmental reports of a similar character make the solution of the various problems of manage-

ment more sure and accurate. The periodicity of these departmental reports may vary; but in most cases they are rendered monthly. Some accountants prefer to make such reports every four weeks, thus making a total of thirteen equal periods a year.

6. *Labor reports.*—Many of these departmental reports can be abstracted from the general accounts or from subsidiary ledgers with little trouble; but there are other reports that are very useful that must be specially compiled. Most of the information for these reports, as has been noted, is found in the records of the cost system. One of the most useful of this class of reports is the labor report, Figure 16, which is usually compiled weekly. The manner in which this report is compiled may illustrate the general method of consolidating returns into reports. In every shop there must be some method of obtaining a record of each man's daily performance. In some cases this is recorded in a book by a traveling timekeeper, but the more modern method records the result of each man's work on small work cards or time cards as they are commonly called. These are collected daily and are sorted first by workmen's names or numbers so as to make up or check the pay-roll, and resorted afterward according to production order numbers so as to distribute the wage costs against the production orders to which they belong. If now the time slips or work cards that are made out by the men who actually do productive work are sorted according to the several lines of product produced, the

BROWN MFG. CO.

LABOR REPORT — WEEK ENDING_____

ACC'T. NO.	CLASS OF LABOR	WEEK ENDING	WEEK ENDING	WEEK ENDING	SAME PERIOD LAST YEAR
	DIRECT LABOR				
A	A.C. GENERATORS				
B	INDUCTION MOTORS				
L	DIRECT-CURRENT GENERATORS				
M	TRANSFORMERS				
RA	ARC LAMPS				
UA	SMALL MOTORS				
S	LIGHTNING ARRESTERS				
O	MISCELLANEOUS				
	UNIT COST DEP'TS				
	IRON FOUNDRY				
	BRASS FOUNDRY				
	TOTAL DIRECT LABOR				
	MANUFACTURING EXPENSE				
200	FACTORY SUPERVISION				
201	STENOGRAPHERS				
202	PRODUCTION CLERKS				
203	COST CLERKS				
204	STORES CLERKS				
205	SHIPPING CLERKS				
206	OTHER CLERKS				
207	OFFICE BOYS				
212	FOREMEN AND ASSISTANTS				
213	INSPECTORS				
214	ELEVATOR AND CRANE MEN				
215	WATCHMEN				
216	GATEMEN				
217	CLEANERS AND OILERS				
218	HELPERS AND LABORERS				
219	SHIPPING CLERKS AND HELPERS				
220	OUTSIDE-CONSTRUCTION MEN				
221	PACKING				
222	YARD TRANSPORTATION				
223	STABLE AND GARAGE SERVICE				
224	FACTORY ERRORS				
225	FIRE DEPARTMENT				
226	ALL OTHER SERVICE				
	TOTAL MFG. EXPENSE LABOR				
	POWER HEAT AND LIGHT				
	MAINTENANCE OF PROPERTY				
301	BUILDINGS				
302	PIPING AND WIRING				
303	MACHINERY AND TOOLS				
304	PATTERNS				
305	MISCELLANEOUS				
	TOTAL MAINTENANCE OF PROPERTY				
	TOTAL INDIRECT LABOR				
	PLANT INVESTMENT				
	OPEN ACCOUNTS				
	ENGINEERING				
	EXPERIMENTAL				
	TOTAL OPEN ACCOUNTS				
	TOTAL PAYROLL				

FIGURE 16. LABOR REPORT

first section of Figure 16, headed "direct labor," results If also the time cards of all men who do indirect labor, such as oiling, sweeping etc., are sorted according to the several classes of such labor, the items in Figure 16, under the heading "manufacturing expense" are secured. Other items are found in a similar manner.

This last sorting process can be greatly facilitated by giving distinctive colors to the several classes of work cards so that they can be sorted by color instead of by numbers. This is especially true since in this case only total results are desired. The labor report is a classified statement of all expenditures for labor; it enables the manager to see at a glance where the money that has been paid out in salaries has gone and to keep a check upon all such expenditures. Such a report is made more valuable if compiled in a comparative manner. Thus, if the record of preceding weeks is shown as indicated in Figure 16, or if the average of former records or the records of corresponding periods of the preceding year are given, the general tendencies are much more clearly indicated.

7. *Interpreting labor reports.*—Care should be taken, however, in drawing conclusions concerning different classes of labor on the same report and at the same period. Thus, the rate of indirect to direct labor is often taken as a criterion of efficiency in production. While indirect labor must always be carefully watched, and while the ratio just mentioned is often an important indication of tendencies, it is not

always an indication of increasing or decreasing efficiency. Suppose, for instance, that certain operations are being performed on cheap standard tools by high-priced workmen in such a manner that the direct-labor cost is large but can be accurately charged off against the respective job-order numbers under which the work is done. Suppose also that because of increased quantity it has become possible to transfer this work to high-priced automatic machines, located in the automatic-machine department where, because of the nature of the work, all labor is of the indirect kind and is not chargeable against specific job orders. The direct labor formerly charged against this class of product is now replaced by an indirect labor charge, and perhaps a heavier machine-rate is imposed because of the more valuable equipment. The ratio of indirect to direct labor as shown on the labor report would be increased, yet the cost of the product may be greatly reduced because of this change in manufacturing methods. Such criteria as these are of value only when conditions are not changed and they should, therefore, be carefully interpreted.

8. *Lost time.*—In some enterprises the matter of lost time is an important factor for the reason that lost time either of men or machines is a measure of the efficiency with which the enterprise is operated. In certain advanced forms of cost finding, as is explained in the volume on that subject, this information is obtained as a portion of the routine of operation, but even where such advanced methods are not

in operation, it is often desirable to have all idle time reported regularly and systematically. A good workman who is absent a large portion of his time may not be so valuable to the employer as one who is mediocre in his work but faithful in his attendance. A machine that is idle a large part of the time, either from lack of work or because it is constantly breaking down, should be carefully investigated. It is often necessary to retain a large machine that is used only occasionally because of certain operations that are essential to getting out the line of products, but there is no doubt that a careful investigation of the time lost thru idleness of the larger tools would often result in the discarding of some of them or in an effort to increase the sales of the product for which they are suitable.

9. *Material reports.*—The purchase analysis sheet, Figure 6, gives the manager a clear exposition of all materials purchased as well as the general disposition of this material. This may or may not be sufficient for his purposes. It may be necessary to follow the disposition of the material further and other reports may be needed.

Material may be wasted as a result of several causes, as for instance, faulty design; changes in design, which leave on hand special material that cannot be used; and the spoiling of material by poor workmanship or bad storage. There is also an unavoidable loss, due to fabrication, in the form of cuttings, scraps from punching, remnants, etc., which may represent

more value than the manager realizes. In some industries the amount of material wasted in fabrication is an important index to the efficiency of manufacture. The disposition of scraps and cuttings is often an important matter, especially where such scraps can be reworked into smaller products.

These sources of loss will serve to indicate the character of the special material reports that may be valuable. Thus periodic reports of all special material on hand, both active and inactive, may save large sums of money, especially if the material is of great value as in the case of copper supplies. It may be desirable to have all material going into each line of product classified and reported in the same manner as that employed to report labor by classes and as illustrated in Figure 16. A comparison of the material values with the number of units produced should be as valuable as a similar comparison based on labor.

10. *Character of material reports.*—Obviously the particular kind of material reports that will be most serviceable will depend on the industry and upon the particular conditions found in that industry. The form of the report blanks also will depend largely upon circumstances. In most cases it is an easy matter to create a blank that will record the desired information, if this information is clearly defined. No effort, therefore, is made here to illustrate blank forms of this kind, for usually they are very simple in character. It is desired, however, to call special attention

to this phase of industrial management which is often overlooked and neglected. One reason for this is that, too frequently, managers are prone to lay too much stress upon the money paid out for labor. Many a manager who will endeavor to keep his wage list down to a minimum and who will use every effort to obtain the last ounce of return for this expenditure is carelessly indifferent to the material values involved and especially to the material wastes. It is always difficult to make the material-cost summaries of the cost books agree with the material-cost summaries of the general books. No doubt, the lack of agreement can in many cases be much lessened by more careful investigation of what disposition is actually made of all material purchased.

11. *Spoiled work and defective material.*—In many factories it is the custom to charge off spoiled work or defective material to the particular job to which it is incident and to do nothing further about the matter. It is fully demonstrated in the volume on "Cost Finding" that this practice leads to inaccurate costs. But aside from this reason, such losses should be carefully reported to some one in authority. A report on spoiled work should give full information regarding it, the names of all men concerned and the reasons for the loss. This is desirable for two reasons. Whether the workman who spoils a piece of work is penalized or not, it is good policy to let it be known that a record is kept of all spoiled work as a check on carelessness. If, on the other hand, the loss is due to

a defect in a machine or process, it should be made known and corrected at once.

Defective material should also be reported promptly for much the same reasons. If the material has been purchased, it may be desirable to make a claim for reimbursement, and in any case the purchasing agent should know of the matter. If the defect is due to ineffective shop processes or methods, it is highly necessary that these be corrected. Thus a bad casting may be due to no fault of the molder, but to the design of the piece; and where a given casting is repeatedly found to be faulty, a report will usually bring this to the attention of those whose duty it is to correct the matter. Reports on spoiled work and defective material are closely connected with the work of the inspection department. In some cases where a number of duplicate parts are put thru the factory in a lot, a continuous record is kept of the progress of the lot from process to process. The report is, consequently, a history of the losses thruout fabrication. This procedure may be of great value where the work is of a refined character and is inspected after each operation; it is especially important in cases where the workmen are paid by the piece.

12. *Expense reports.*—A very important class of reports which are based upon the cost system are those that give an analysis of the expenses of operation. The labor report, Figure 16, gives a summary of expense labor, but it is often desirable to know something more concerning both labor and material that

have gone into this important class of expenditures. A general summary of all expense items by classes may be sufficient for the purpose or it may be desirable to have detailed departmental reports. Figure 17 illustrates such a departmental report analyzing the cost of operating a factory power house supplying heat, light and power to several departments. It shows the cost by items, monthly, and also the totals by departments. Reports of this kind are of great variety and may be exceedingly useful to the manager.

In its best form the expense report will place before the manager a condensed statement of all expense items. These expense items in a manufacturing plant are many and the amount of detail allowable in making up the report should be a matter of careful consideration. In large enterprises a condensed expense report should have back of it departmental reports such as are illustrated in Figure 16. Obviously the larger the enterprise, the more detailed must be the subdivision of expense items and the greater must be the care exercised in laying out a system of expense accounts which shall culminate in one concise, accurate report portraying the changes that take place in this important factor of manufacturing costs.

13. *Special reports.*—There are many other reports that are of great service, as for instance, the progress report which gives a statement of the condition of all orders in process of production. In addition to these regular reports which should be made up at stated

intervals, the manager may find much help and guidance in special reports that are compiled for a single

EXPENSE-ANALYSIS SHEET
POWER, HEAT AND LIGHT

FORM_____
DATE_____

ACC'T NO.	CHARACTER OF EXPENSE	FOR MONTH OF_____		FOR PERIOD TO DATE	
	LABOR				
	ENGINEERS				
	FIREMEN				
	HELPERS				
	REPAIR LABOR				
	SUPPLIES				
	COAL				
	SHOVELS				
	BARROWS				
	OIL				
	MISCELLANEOUS				
	REPAIR MATERIAL				
	BOILER REPAIRS				
	ENGINE REPAIRS				
	GASKETS AND PACKING				
	MISCELLANEOUS				
	DEPRECIATION, INSURANCE, ETC.				
	TOTAL				
DEP'T	DISTRIBUTION BY DEPARTMENTS				
A	PER CENT OF TOTAL 6				
B	" " " " 12				
C	" " " " 11				
D	" " " " 27				
E	" " " " 25				
F	" " " " 19				
	TOTALS 100				

FIGURE 17. POWER HOUSE EXPENSE

specific purpose. Thus, in case the cost record shows that money has been lost on a contract, the cost keeper should be able to furnish a detailed statement of all

labor and material that has gone into the work as well as the expense charges incident thereto. Such a statement is invaluable in finding out what has gone wrong and in proceeding to remedy the difficulty. Until a manager has made a study of the cost of producing a given piece of product thru such a report, in company with the designer, the toolmaker, the manufacturing superintendent and others interested, he will not fully appreciate the value of such reports.

14. *Form of reports.*—The manner in which statistical data are presented is of great importance. Reference is not made to the particular form or shape of the blank on which the report is made, but rather to the philosophy underlying the making of reports. The blank form that is satisfactory in one place may be entirely inadequate in another; and the copying of blank forms from any system to be used elsewhere should be done with caution. There are a few underlying principles, however, which if well understood will enable any manager or cost accountant to originate blank forms which will aid materially in interpreting the statistics presented. Some of these principles will now be briefly discussed.

All statistical data gain in value if presented in such a manner that contrasts and comparisons can be drawn. Thus in Figure 16, the data for the week for which the report is made can be readily compared with the two preceding weeks and with the corresponding period of the previous year. In Figure 17, a comparison between the data for the given month

and the average for the period since the first of the year can be made with ease.

This method of contrasting results of a given period with those of some other period is quite common. Expense records are frequently compiled in this manner, the idea being that any change in values will be more quickly noted and inquired into if necessary. The weakness in this method of comparison is that it is based on the assumption that other factors remain constant and this may or may not be true. Thus in the report shown in Figure 17, which is a typical report of this kind, there is nothing to show that conditions have remained constant and there might be excellent reasons for wide variation in the report, tho the form in which it is presented assumes that such variation should not occur, or if it does occur that it should be inquired into. While such methods of comparison are useful and may suffice for some purposes, they are not sufficient for others where the standards of measurements must be more definite.

Thus it may be important to know the value of the output of the factory, but it is much more important to know the output per unit of capital invested or per dollar of wages paid or per employe at work. The total amount of coal burned in the power plant for the month as compared with that of other months may be worth knowing; but the cost of the coal burned for each horse-power-hour that is developed is a much more intelligent criterion of the efficiency of the power station. The cost of a given article is

always an important matter, but its comparative cost, as judged by other performances may be equally important. It will be noted that this form of comparison is very different from the method that has just been discussed and which is illustrated in Figure 17. In the first method the comparison is made between performances of a similar kind neither of which are exactly like any other performance. It is, in fact, a comparison of variables. In the second case the comparison is made between the performance considered and a standard of some kind which is fixed and does not vary.

15. *Management standards.*—The application of standards to problems of management should be carefully noted and the selection of these standards is a matter of prime importance. The possible error in using the ratio of indirect to direct labor as a criterion of efficiency which has already been discussed in Section 7 of the present chapter is a good illustration of this matter. Such a ratio may or may not be an indication of efficiency since both factors may vary and since there may be good justification for such variation. In the case of the power house just mentioned, the standard of reference does not vary, since the performance which the engines and boilers should make is well known or can be obtained and comparison is absolute and not relative. The amount of coal for each horse-power-hour that should be consumed under normal conditions in a given power house can be determined with fair accuracy, and any departure

therefrom should be explained on the costs analysis sheet and without regard to past or future performances. It is obvious that the cost per horse-power-hour could easily be applied as a criterion of efficiency to the data presented in Figure 17, if the output of power has been included.

In a similar manner it is much more satisfactory and conclusive to judge industrial data by fixed standards than by previous performances in which the conditions may or may not have been the same. Standards of this kind can usually be found and such standards are in use in many manufacturing organizations. The ratio of the value of the output at factory cost to the value of the inventory or to the number of workmen employed may furnish a much more definite standard of comparison than is obtained by comparing the output during various periods. The amount of wages paid or the number of square feet of floor space employed may also be used in certain cases as a basis of comparison, tho the latter is more valuable, perhaps, in comparing the output of different factories of the same general character. The tendency in modern industrial work is to find standards of performance of this character that can be used as a criterion of work and also as a basis of predicting performance.

16. *Graphic methods.*—The comparison of statistical data with one another and with a common standard is often greatly facilitated by graphic methods. This is particularly true when it is desired to

show the history of a given performance or of a set of related results. These methods make it much easier to compare different sets of data and they indicate tendencies much more clearly than do tabulated statements which are always difficult to summarize visually. Figure 18, for instance, shows graphically the history of a set of costs incurred in operating a power house and similar to those listed in Figure 17. The tendencies of such accounts can be checked much more readily by this method than when the same values are expressed in tabulated figures. In the illustration, Figure 18, a sudden rise is shown on the curve of totals about February 28th. The origin of this rise is easily traceable in curves 1 and 3 and evidently is due to some repair work.

More significant, however, is the curve number 6, which shows the cost per horse-power per week in cents. Normally this cost should be about 38 cents per horse power, and if the manager has no other check upon the performance of the power house, he could form a good idea of the efficiency with which it was being conducted. It would not tell him, however, whether the power was being used in an economical manner, and he would require other data if he wished to find whether it was so used. The application of these methods to other kinds of industrial data will be obvious. The graphic method is of very wide application and is very useful wherever a large number of figures are to be assembled in tangible form. In some cases it will be found helpful to plot the average

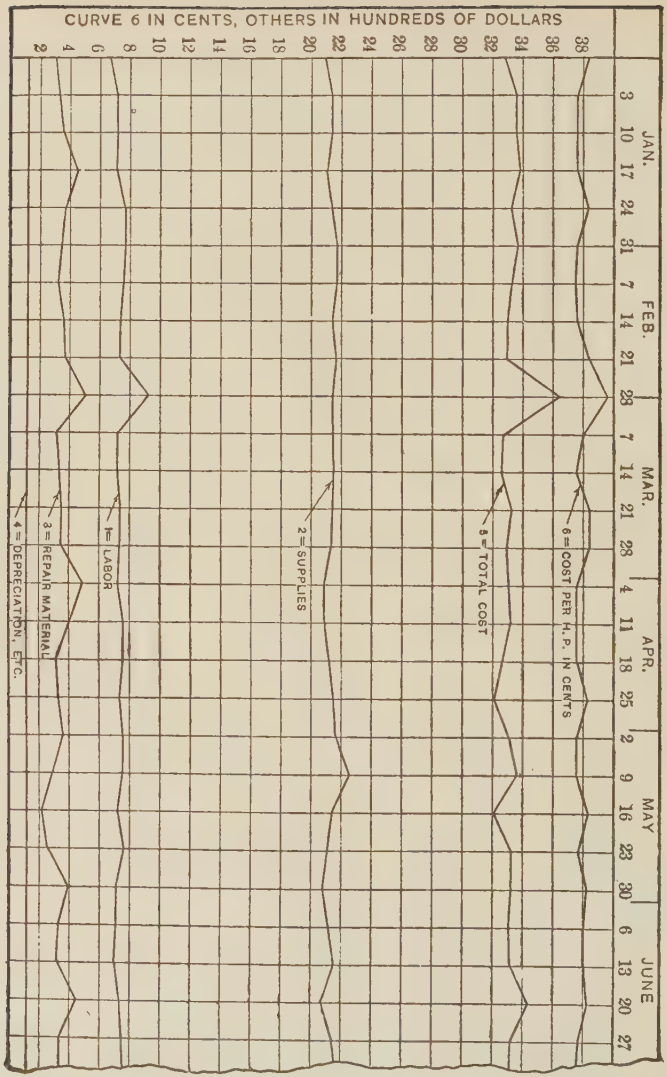

FIGURE 18. GRAPHIC RECORD OF POWER-HOUSE EXPENSE

values of the running data under consideration, and again in others it may be helpful to plot the accumulated total up to the time considered.

17. *Making use of reports.*—It will be noted that it costs money to compile reports, and for that reason great care should be used in selecting the reports that are considered necessary for managerial control. Once the selection is made, the reports should be compiled regularly with scrupulous regard to accuracy and then they should be used. Unless reports are of some service and unless they tell something of value to the management of the business they should be discontinued, as they are a waste of time and money.

On the other hand, if a report is useful, it should be used to its full worth. Reports are tools suited or unsuited to their work, and their degree of usefulness depends upon how intelligently they are used. Perhaps the best method of making use of a report is to have it discussed by a committee of those interested in and competent to discuss the data presented. This has already been alluded to in Section 1 of the present chapter, which should be reread in this connection.

REVIEW

Explain why statistics and reports have become necessary in modern industry.

What financial reports are most valuable?

What should be the contents of department reports? Of labor reports? Of material reports? Of expense reports? What purpose does each serve?

Explain advantages and limitations of graphic methods.

When is the preparation of reports a useless expense?

CHAPTER XVI

LOCATION OF INDUSTRIAL PLANTS

1. *Economic importance.*—Industries of all kinds grow naturally out of the needs of some community. In a new country, therefore, it is to be expected that such manufacturing industries as exist, usually run on a small scale, will be found near the populations they serve, since transportation facilities are usually meagre and expensive. The exact location of an industry in a new country may be largely a matter of chance. But once an industry has taken firm root in any place, there will grow up around it a combination of influences that will make it a powerful competitor against those founded later on in more favorable locations. This is well illustrated in many industries that still flourish in our older states, tho there are other places which possess superior advantages in many particulars.

As a country develops industrially, and as transportation facilities become more effective and cheaper, the location of an industrial enterprise cannot be left to chance, but is a matter to be carefully weighed in all its bearings. It can no longer be left to personal opinion or guesswork, but must be governed by strict economic considerations. This is particularly true in

establishing an industry in which the inertia of age has not as yet appeared, but where rigid economy must be practiced to insure success. In such cases many influences must be considered, carefully weighed, and a final decision made only after all factors have been considered. Once the decision is made and the plant established, the decision is in most cases irrevocable, because of the difficulty and expense of moving.

2. *Concentration of industry.*—An examination of any manufacturing country will show that industries tend to concentrate or localize, forming industrial centers which are devoted to the production of a limited line of products. This phenomenon is not peculiar to modern industry, but was common under handicraft production and is still common in all lands, even where modern methods are not in vogue. In Russia there are 500 villages devoted to the various branches of woodwork, nothing being made, for instance, in one village except spokes for the wheels of vehicles; and in another, nothing but vehicle bodies. The localization of industry in old manufacturing countries, such as England, is well known. In this country the great textile centers are found in New England; Connecticut is the center of brass working and Pennsylvania leads in carpets and steel products. An analogy to this general characteristic of industry is seen in the way in which the industrial activities of a city tend to group themselves. Thus the wholesale district is distinct from the retail district, and in

the wholesale district itself will be found groups of industries that have similar characteristics. Thus there will be a wool district, a leather district, and on the manufacturing side machine shops will form one center, planing mills and woodworking another, and so on according to the industries and commercial activities of the city. This localization within the city is not, however, necessarily caused by an extension of the influences which have localized industry as a whole in that particular region, as these reasons may be different from those that cause localization in the city itself. But the analogy is significant as showing how a complex system of influences may produce very definite results and emphasizes the necessity of studying these influences and results before locating an industry.

3. *Migration of industry.*—Another important characteristic of industry is its tendency to migrate under certain circumstances. The manufacturing industry naturally tends, to some extent, to follow the markets, and this explains in a measure the fact that the center of manufactures has steadily moved westward in this country as has the center of population. In 1850 the center of population was in the western part of West Virginia while the center of manufactures was in the southern central part of Pennsylvania. In 1900 the center of population was near Columbus, Indiana, while the center of manufactures was near Mansfield, Ohio. The census of 1910 locates the center of population near Bloomington,

Indiana, and it is reasonable to suppose that the center of manufactures moved west a similar distance in the preceding decade. But in addition to this general movement the major portion of entire industries may leave one locality and move to another because of the economic advantages offered by the latter. For this reason New England is no longer a predominating factor in certain lines of production that had their origin in that region; cheaper material and better market relations have given more westerly states such an advantage as to cause in some cases an almost complete removal of some industries to western locations. On the other hand some of these older states have easily held a foremost position in the manufacture of products for which they possessed no raw material, against keen competition from newer states which possessed the advantages of raw material in abundance and equally good transportation and market facilities. New England is still supreme in spinning and weaving, in jewelry and silverware, in brass working and shoe making, tho all of the raw material for these products must be obtained from elsewhere. The trend of manufacturing, geographically, is therefore an important consideration in locating a manufacturing plant or in moving an old one. Obviously it would not be a good policy to move into an area where the business was waning, as the presumption naturally is that the location does not possess economic advantages comparable with other places.

4. *Causes of localization of industry.*—The great-

est source of information concerning the localization and migration of industry is the United States census, and every manufacturer who is confronted with the problem of locating an industry should without fail consult these volumes. The census of 1900, in analyzing the statistics bearing on these matters, lists seven advantages which, in varying combinations, may cause a localization of industry, namely:—(1) nearness to materials; (2) nearness to markets; (3) water-power; (4) a favorable climate; (5) a supply of labor; (6) capital available for investment; (7) the momentum of an early start. Clearly the most advantageous combination of these and other factors that may affect the location of the industry is that in which the sum of the cost of raw material delivered at the plant, the cost of manufacture and the cost of marketing is at a minimum.

5. *Nearness to raw material and to markets.*—All other things being equal, an industry naturally locates near the market which it expects to serve; for, commonly, the founding of an industry comes either because of a demand from a market or from an effort to create such a demand. But the location of the supplies of raw materials is always an important economic factor, and the location selected for the industry is in many cases a compromise largely because of questions pertaining to transportation. There is no economy in shipping bulky raw material long distances, if the major portion of it is to become waste during the process of manufacture. Paper mills are,

therefore, found near the forests, just as packing houses are found near the stock-raising regions. On the other hand, the wool grown in the western states may, perhaps, be economically manufactured in the eastern part of the country where labor and other facilities abound. The copper ores of Montana are reduced to copper at or near the mines because the cost of transportation of the great quantities of ore needed would be prohibitive. But the ingot copper is shipped to the manufacturing centers of the eastern portion of the country—many of the manufactured products that result going back again to Montana.

A most interesting example of an economic study of this kind was the location of the great steel plant at Gary some years ago. The state of Pennsylvania has long held the leading place in the manufacture of iron and steel, the center of this industry being in Pittsburg where the raw materials were close at hand. Somewhat over half a century ago great deposits of excellent iron ore were discovered at the upper end of Lake Superior. By 1889 this region produced and shipped over half of the iron ore used in this country, much of it going to Pittsburg, because the ore was so rich that it was possible to pay freight rates and still compete with Pittsburg ore. In 1908 the United States Steel Corporation after a careful survey of the problem built the greatest steel plant ever constructed, at Gary, Indiana, about 25 miles from Chicago. Here ore coming by boat from the Lake Superior region is unloaded directly at the steel

plant and meets the coal and coke coming by car from the Pittsburg region. The Gary plant, therefore, has minimized the cost of handling the raw materials, while at the same time it is near the markets and is situated on or near several large trunk railways. It will be clear that the influences of materials and markets grow smaller as the question of transportation becomes less, economically. If the transportation charges are small, then one or the other, or both of the factors, labor and power, may be the controlling influences in locating the industry, for both raw material and finished product may be economically transported long distances to utilize these factors and yet find a market.

6. *Influences of water power.*—The influence of water power in localizing industry was more apparent in the past than it is at present. Before the days of steam power practically all industries requiring power necessarily sought water power in a location. New England, no doubt, owes much of her manufacturing greatness to the abundant water falls of that region. The use of coal and the fact that industry has to a large measure outgrown the water powers of the eastern section have given other localities an equal if not a greater manufacturing advantage. But all water powers are sure to be of increasing importance as coal becomes more expensive. The grouping of great industries at Niagara Falls has probably only begun, and many of the western cities that owe their start to water falls may, therefore, look forward to con-

tinued prosperity as the tributary country develops agriculturally. Cheap steam power or cheap fuel for other purposes may also be an important factor in industrial location.

7. *Influence of climate.*—In some industries the effect of climate on plant location was greater in years gone by than it is at present. Thus formerly the climate had an important influence in the textile industries, but now such factories are kept at the proper degrees of temperature and humidity by artificial means. Of course, a healthful and invigorating climate is conducive to increased production, and for that reason in some measure, perhaps, New England has retained some of her commercial and manufacturing supremacy. A mild climate, on the other hand, may have peculiar advantages. Thus shipbuilders may work in the open in San Francisco in comparative comfort all the year round, while such work is conducted in New England in the winter with great hardship. The cost of heating a factory in a cold climate may also be considerable.

8. *Influence of labor supply.*—The location of certain kinds of industry does not appear to be much affected by the question of labor. Thus we have many examples of large industries, such as smelting and cement plants, having been located because of economic considerations of markets, raw materials, and transportation facilities; and the working population was moved to the plant location from elsewhere. This can be done in industries where the majority of

the labor is of the semi-skilled and unskilled variety. But it is exceedingly difficult to induce skilled labor to migrate. It takes time to build up an industrial community of skilled workers and, as a rule, skilled workers do not wish to leave their environment without a considerable increase in wages, or other compensations. Even when they do migrate, they easily become discontented and return to their old surroundings. The pioneer spirit is not strong among skilled industrial workers.

It may be good policy, therefore, to establish an industry in a location that is far from advantageous as regards power or raw materials, perhaps, if thereby the proper supply of labor can be obtained. The tenacious hold that New England has maintained on some industries against strong competition is due in no small degree to the abundance of skilled labor to be found in that section. A large supply of skilled labor tends, more than any other influence, perhaps, to give stability and inertia to skilled industry.

9. *Influence of capital.*—It is axiomatic that modern industry cannot be started, or flourish after being started, without a supply of capital. In the case of very large enterprises which are usually financed in the large money centers, the plant or plants may be located a long way from this center; but in the case of small or medium-sized enterprises, available local capital is an important factor. A prosperous town or city where money is being made rapidly in other industries is always a favorable location for an indus-

try, everything else being equal. There is often a considerable advantage in having much of the stock held locally. The presence of good banking facilities is also desirable, since such facilities afford opportunity for making the capital of the community available for investment.

10. *Momentum of an early start.*—It has already been noted that many of our industries were located originally by chance circumstances. The textile industries of Providence and the shoe industries of Lynn are illustrations of this. Obviously there were other places in the new country that were equally suited to these ventures. But these enterprises prospered largely, perhaps, because of the men who founded them; others grew up by imitation, or as offshoots of the parent industry. After a time subsidiary occupations sprang up in the neighborhood and presently a large amount of local capital became invested. A large body of workers skilled in these industries became permanently settled in the neighborhood, and as a culmination of these growths the enterprises acquired a great momentum that has carried many of them along to this day in spite of competition from other locations which possess superior advantages.

Many New England industries have stubbornly and successfully maintained their lead largely because of the inertia of such an early start. This influence is not imaginary, for in a general way people are very likely to have confidence in an industry that is being

started in a neighborhood where similar ventures have succeeded, and there is often much justification for this belief, even tho it be shown that other localities possess superior advantages. Conversely the failure of an enterprise is likely to discredit a locality as a site for similar undertakings.

11. *Localization within a given area.*—The influences that have been discussed operate to locate industries within comparatively large areas. It is seldom that any one or two of these influences alone determine the location, but usually there is a combination of these influences that will serve as a guide to an economical solution of the problem. The exact location of an industry within a given area is usually determined by other influences which must be considered with those that have been discussed. Among the many additional considerations that may thus influence the exact location are the following:

(a) Transportation facilities
(b) Initial building requirements and possibility of expansion
(c) Local labor supply
(d) Dependence on other industries
(e) Financial considerations
(f) Relative value of community restrictions and community aid
(g) Relative value of local markets.

A clearer idea of the relative influences of these several items may be obtained by considering the rela-

tive merits of three classes of location, namely city, country, and suburban; and the following quotation from the writer's "Principles of Industrial Engineering" offers a condensed statement of these merits.

Cities, being natural centers for trunk lines, or water transportation, usually offer superior advantages for obtaining raw material and for shipping finished goods. An abundant labor supply is obtainable, as compared to other locations. If the plant is small and dependent on other industries the city offers superior advantages when these other articulated industries are present. It is easier, often, to finance an undertaking in the city; cities offering larger fields for obtaining subscriptions to stock or for obtaining special inducements to locate, such as exemption from taxes or large cash bonuses to assist in starting the enterprise. If the plant is small and is supplying the local market only, the city offers market advantages that would not be important to a large plant. A plant located in a city enjoys municipal advantages such as good streets, gas, sewers, police and fire protection, etc.

As opposed to these advantages the city location has the disadvantage that land is high-priced and it is often difficult for large works to secure a site within a city where buildings exactly suited to the purpose can be erected without great expense; and if the city is a growing one the taxes, in time, make the location too expensive. City restrictions regarding smoke and other municipal regulations must also be carefully considered. While labor may be abundant in the city, the cost of living and hence the wages paid, are, in general, higher than in the country.

The advantages of a location in the country are not so numerous as those of the city, but they may be of paramount importance. Thus, if a water power is obtainable or if a supply of pure water is necessary, as in paper making, a country site may be desirable. Land is cheap in the country and, hence, the factory can be built to suit the exact needs of

the industry and ample provision can be made for growth. Taxes are low and restrictive ordinances are not likely to hamper the activity of the plant. The larger the plant the less dependent it is on other industries and, hence, the country site, in general, appeals to the large operator more than to the small one. The undesirable neighbors can be more easily avoided in a country location, and the danger from fire and other hazards resulting from surrounding industries are also minimized.

On the other hand the labor supply of the country is usually a troublesome problem. The city offers advantages and amusements to the working classes that cannot be had in the country. An effort is often made to offset these attractions by building model factory villages where employees may acquire homes on easy terms and enjoy the healthful life of the country. Of course, the employer who engages in such an enterprise must expect to feel a greater responsibility toward his employees than he would in a city where the bond is much looser. But such work as this is worth while and no doubt the near future will see a great amount of decentralizing of industry from the thickly congested centers in favor of country locations. Just as it is difficult to induce labor to leave the cities, so it is difficult to attract them away from good country industries if the conditions of life are made attractive; and labor troubles are likely to be less in a country location than in a congested city.

The suburbs of many cities offer a compromise between the city and the country and possess many of the benefits of both. Land can be obtained at a price far below city property, and trolley lines have made living in the suburbs cheaper than in the city and yet made it possible for the suburban dweller to take advantage of the attractions of the city. An examination of any of our large cities will show an immense amount of manufacturing in the suburbs, this location being particularly advantageous for fair-sized plants.

From the above it will appear that the city location, in general, offers greatest attractions to the small plant, the suburbs are best adapted to fair-sized plants and the country

offers by far the largest attraction and fewest disadvantages to the very large plant provided an adequate supply of labor can be obtained.

REVIEW

What influences ought a prospective manufacturer to consider in selecting a location for the factory?

Where is the center of manufactures now located? What have been the causes of the westbound movement during the past fifty years?

Why did the United States Steel Corporation locate at Gary, Indiana? Was it a wise move? After all, what should be the deciding factor in determining the choice of location? How does New England maintain its hold on its skilled industry?

CHAPTER XVII

ARRANGEMENT OF INDUSTRIAL PLANTS

1. *Old methods.*—The discussion in Chapter VIII of the problems involved in passing work thru the factory in an economical manner makes clear the importance of having such an arrangement of building and machinery as will permit the work to flow naturally, so to speak, from process to process. The degree to which it is possible to adapt the buildings and machinery to the needs of the industry depends largely upon the character of the work. Furthermore, the desirability of adapting a building to conform closely with a chain of processes depends in a large measure upon the permanency of occupation of the building. In crowded cities where many small industries occupy rented quarters and where there is considerable possibility of the tenants moving, the owner of the building naturally hesitates to build specially arranged buildings. Usually, therefore, such buildings are arranged to suit average conditions. There are, moreover, in large cities many forms of industry that require floor space only, the exact shape of the floors being of little moment since sequence of processes is not important.

It is common experience, however, that when a

manufacturer acquires such an average plant, he immediately tries to rearrange it to suit his work. Today every manufacturer who builds a new plant makes an effort to have this plant conform as closely as possible to the needs of the processes. Simple rule-of-thumb methods of proportioning and arranging manufacturing plants will no longer suffice, and the work of designing factory buildings, selecting and arranging the machines and processes is now recognized as a distinct calling analogous to that of the architect.

2. *Classification of processes.*—Manufacturing industries may be divided into continuous-process methods and intermittent-process methods and the problems of plant arrangement may be made clearer by a brief consideration of these characteristics. In a continuous-process industry the raw material passes in at the receiving end of the plant, is worked continuously, and appears at the shipping end as finished product. It will be clear that a given plant might have one or more continuous processes in operation tho this is comparatively rare. A continuous process, furthermore, may start with certain raw material or materials and produce several products, receiving additional material at various stages of the process. This often occurs in analytical processes, so called, that are engaged in making several products from one basic raw material, as may be seen in industries making products from salt as a basis. In a reverse way continuous processes may start with several kinds of raw material and build them up into one product, as is

illustrated in paint-making factories and factories for printing wall paper. This latter class are known as synthetical processes. Continuous processes in general, however, deal with a few materials only, these materials flowing, as it were, thru the factory in an unbroken stream and passing out of the factory in the form of a limited number of products. In such processes the sequence of machines and processes and the arrangement and construction of the buildings can be made to conform very closely to the needs of the industry. This is well illustrated in ore concentrators where the building conforms very closely to the requirements of the machinery. Sugar refineries, rail mills, flour mills and packing houses, are usually built to conform so closely to the needs of the processes as to be useless for other work.

Intermittent industries or interrupted industries as they are sometimes called may employ many kinds of material, the combination varying from time to time with the work on hand. These materials may be carried to any desired degree of completion; they may be stored as finished or semi-finished product, if necessary, and assembled from time to time as the market demands dictate. The finished product may cover a very wide range both as to size and character. Agricultural implement works and electrical manufacturing plants are good examples of intermittent industries. This class of industry includes probably the larger part of organized production.

At the extreme of intermittent industries are the

simple assemblying industries referred to in the last section where floor space is the main requirement, little or no machinery is employed, or where the machines used are small and the production centers are not closely connected by sequence of process. In some of these assembling industries the density of the workers is almost the only restriction on arrangement, and in many cities legal regulations are in force to prevent over congestion in such work. The fur and feather industry and the artificial flower industry are good examples of these simple assembling processes.

The classification made in the foregoing is not, of course, clearly defined, but it represents the extreme types of industrial construction. Between these limits come all manner of combinations of these extreme methods, and some plants have many elements of both included in their make-up. Each plant presents a different combination of needs.

3. *Important features of plant planning.*—It is difficult, therefore, to lay down any rules regarding the adapting of buildings and the arrangement of machines and processes that will apply closely to all forms of industry. The best solution is usually a compromise that can be formulated only with an intimate knowledge of the work in hand and of the financial limitations of the enterprise. However, there are a few controlling influences that should be kept in mind in planning industrial plants, the most important of which are the arrangement of processes,

manufacturing service, employes service and the possibilities of expansion and growth.

The arrangement of processes, or process mapping, includes the selection and arrangement of tools, processes and buildings, having in mind the manufacturing requirements of the problem. Manufacturing service includes the auxiliary manufacturing needs, such as power, heat, light, ventilation, storage, shipping, transportation, office facilities, etc., which are required to keep the machines and processes in operation. Employes' service includes all provisions that should be made for the comfort and protection of the workers. While this activity is closely connected with manufacturing service, it will be more convenient to discuss this matter as a separate item later on. The need of providing for expansion and growth is self-evident.

4. *Process planning.*—The first step in laying out a new industry or in rearranging an old one is to map out the most advantageous sequence of processes. In continuous industries this is comparatively easy to do, since the sequence is usually fixed automatically by the character of the industry. The same is true of assemblying industries of the extreme type where there is little or no sequence. In intermittent manufacturing, however, this problem is often most difficult and almost always deserves more attention than is given it. It is often most difficult in these industries to secure a balanced equipment or any approach to a natural flow of material from the receiv-

ing end to the delivery end with a minimum of expense for handling and transporting. When a decision has been made regarding the machines or processes that are to be installed, an outline plan of the arrangement of these processes and the buildings that are to house them can be made. In making this plan, attention

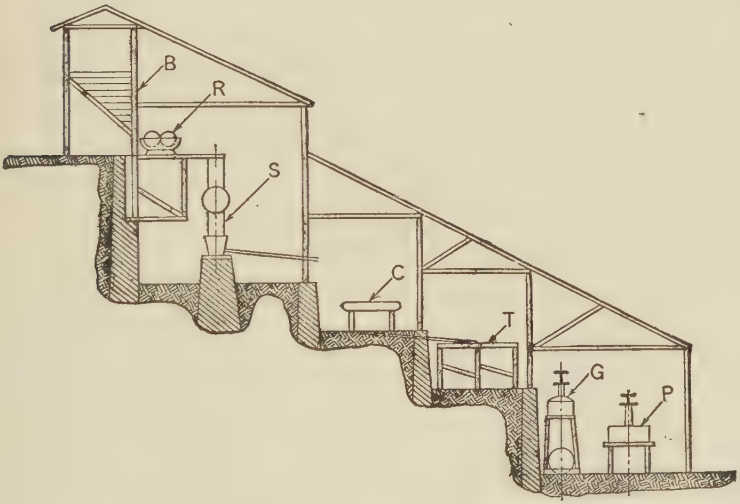

FIGURE 19. STAMP MILL, CONTINUOUS INDUSTRY PLANT

must be had to the character of the ground on which the plant is to stand. Thus Figure 19 shows a rough outline of such a process map for an ore reduction plant situated on a hillside to take advantage of gravity, the ore passing thru the several machines and processes largely because of that force. Figure 20 shows a similar plan for an intermittent process industry in which transportation is in general from left to right,

but in which there may be many small backward movements of material in some classes of work.

5. *Size of floors and buildings.*—The exact size of each floor and of each building will depend on the machines and processes to be installed. This must be determined by the conditions of the case. Thus in Figure 19 the capacity of the machinery in each department must be equal to the capacity in every other, due attention being had to necessary duplication to insure steady operation. In Figure 20, however, there

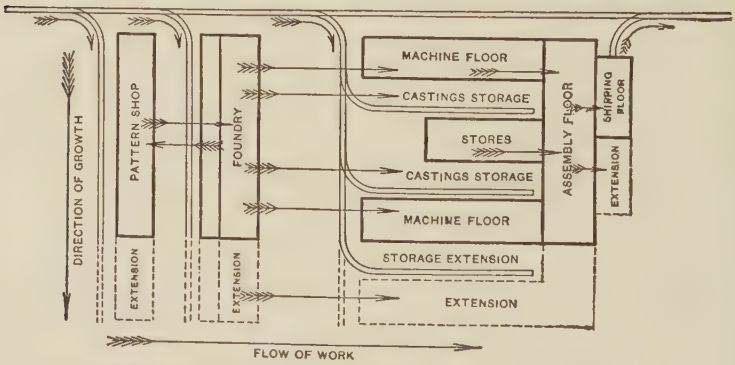

FIGURE 20. DIAGRAM OF INTERMITTENT PROCESS FACTORY

is no criterion of measurement and the number and size of the machines that are to be installed on each floor is a matter of intimate knowledge of the range, quantity and size of work to be performed.

It is common practice in building new factories or in extending old ones to calculate the floor area by reference to other plants of the same kind. Such data are always valuable as a check if their source and

limitations are fully known. But all such rule-of-thumb standards should be used with care and as a check only, since plants of the same kind vary widely. This is particularly true if new machines and new methods for performing old operations are to be installed. It is much safer to make careful computations based on the actual producing capacities of all machines and processes to be installed, using empirical data as a check against errors.

6. *Arrangement of machinery.*—In laying out the arrangement of machines and processes on any given floor due attention should be paid to the logical routing of work thru the equipment and to making it conform to the general flow of work thru the factory as a whole. In continuous-process industries this is comparatively simple, but in intermittent-process plants where the work is variable as to size and character it may be largely a matter of good judgment. A careful study of this problem is essential, however, especially if it is expected to route the work thru by modern methods (see Section 3, Chapter VIII). A convenient method of arranging machinery is to cut out to a scale cardboard forms representing the several machines and processes. These models can be arranged and rearranged until a satisfactory solution is secured. When such an arrangement is perfected the most effective form and size of the building necessary follows from it. If the problem is to arrange a given amount of machinery on a given floor, the method suggested is even more convenient. The problems of

manufacturing service and of employes' service cannot be separated, of course, from the problem of arranging the machinery, and provision must be made for these services in the original layout. It may be remarked in passing that it is good economy to provide liberally for floor space around machines and processes. A congested shop tends to confusion and consequent errors, while it always makes handling and transportation troublesome and costly.

7. *Principles of equipment arrangement.*—While the arrangement of equipment may be a matter of good judgment, there are two distinct principles or methods of grouping machines and processes that greatly influence not only the arrangement of factory floors, and hence the general arrangement of the factory itself, but also the administration of the entire plant. In the first method all machines or processes of the same kind and same approximate size are grouped together. Thus all small lathes would be placed in one group, all large lathes in another. All semi-automatic lathes would be grouped together and all planing machines would form another unit. That is, the arrangement of machinery is according to the processes to be performed. The large automatic machine floors to be seen in typewriter and gun factories are excellent examples of this idea. In the second method the arrangement of the equipment is according to the character of the finished product. Under this arrangement a department that is building, say, arc lamps would have its own equipment

sufficient for all its needs; a department in the same factory building transformers would also have its own equipment; each would be independent of the other, and each would be in a large measure self-sufficient in the matter of machining processes.

The first method is by far the most economical so far as the number of tools for a given output is concerned. There is also a greater possibility of keeping all tools of a kind in continuous operation. The cost of superintendence is, in general, less than in the other method and the workmanship will be better because of the greater possibilities of specialization. This method is peculiarly adapted to mass production where many parts of each kind are to be made, as in typewriter and automobile works. It should be noted, however, that the success of the method depends very greatly upon the accuracy with which the machining is done and this again depends on the character of the equipment and the measuring gauges and standards used. If the machining is not accurately done, the cost of fitting the parts together and correcting the errors by hand work is prohibitive. This method of machine arrangement should not be attempted, therefore, unless proper provision for accurate machining has been made.

Even when the departmental arrangement of machines is adopted as a general plan, it is often necessary to make modifications of the method. Many departments devoted primarily to one kind of work may be made much more effective by the addition of a few

tools of another kind for emergency work. Thus an assembling floor may need a drill-press or a lathe or grindstone on which to make minor corrections and thus save time. In highly-developed mass production this is not necessary or even allowable and the parts should arrive on the assembly floor ready for accurate assembly. The plan of arrangement according to the character of the work to be performed is applicable more generally to special industries and plants where several products that are widely different are produced. In intermittent manufacturing many compromises must often be made for best results and both methods may sometimes be used to advantage.

8. *Final arrangement of departments.*—With the internal arrangements of the several departments tentatively arranged and the approximate size of the several buildings thus fairly closely outlined, the original process map may be redrawn and provision made for transportation and other manufacturing service, and also for the several items of employes' service, such as toilets, washrooms, bicycle racks, etc. These services should be considered from the standpoint of the factory as a whole. Thus storage and transportation thruout the entire plant should be studied as one problem and the arrangement of buildings altered, if necessary, to secure a flow of material from the receiving room to the shipping floor. The location of the power plant, if one is installed, and the general plan of power transmission, lighting, and heating

should be planned with the general project in mind. This is true of employes' service, also, and wash rooms, toilets, etc., while they should be placed so as to be of easy access to the employes, should also be placed with a view to maximum efficiency and ease of supervision. Obviously, no general rules can be laid down for locating these services since each plant is a problem unto itself.

9. *Buildings.*—The exact size of all buildings can now be determined and the details of these buildings can be worked out so as to accommodate the several requirements. The problems of building design, both as to type of building and as to details, have become highly specialized, and if the plant is large the planning engineer should consult an industrial architect on these problems. There are certain considerations, however, that the planning engineer and the owner should insist upon. These are fire protection, light, heat, ventilation, sanitation and appearance.

It would seem to be unnecessary to urge that every precaution be taken to prevent fire and there is little excuse today with modern materials of construction for anything but fire-proof construction. Fire-fighting appliances, sprinkler-systems and other protective devices are part of the equipment of every modern plant and many large plants have a complete equipment of fire engines and trained firemen.

It is good economy to have all buildings well lighted, well heated, and well ventilated. The cold, dark, ill-smelling shops that are still so common are

anything but economical. Money spent in making workmen comfortable pays good dividends. There is no more economy in keeping a clerk well housed than there is in keeping a high-priced mechanic in the same condition, tho many managers still fail to see that this is so. Workmen naturally work better and faster in comfortable surroundings, and this is due in no small degree to the improved mental condition that goes with good surroundings. In many forms of industry such as grinding, plating, etc., laws of most states compel a decent standard of surrounding conditions. These remarks apply in general also to sanitary appliances.

Modern factory buildings have been notorious for their ugly appearance, in fact to many people the word factory is synonymous with all that is ugly. There is in most cases no reason why this should be so, and there is a rapidly growing sentiment that factory buildings should be good to look at as well as useful. It is difficult, of course, to obtain architectural beauty in some forms of factory construction, but much of the ugliness is unnecessary. At the present time in this country, many examples of factory architecture that afford all the facilities that have been enumerated in this chapter also present a pleasing appearance, and in a few cases they attain real architectural beauty.

10. *Provision for expansion.*—A most important consideration in plant design is provision for expansion. It is a costly matter to move an industrial

plant in any case. Yet it is a common experience in this country, where cities have grown rapidly, for large concerns to have to build anew because of the failure to provide sufficient room for expansion in the beginning, and because of the impossibility or excessive cost of securing this room when needed. The manner in which this provision is made is closely connected with plant arrangement. Here, again, no fixed rules can be laid down, because industry is so varied. In many cases, however, it is wise to provide room for growth at right angles to the flow of material thru the plant. Thus in Figure 19, it is obvious that if the capacity of the plant is to be increased it must be done by building a similar set of machines and processes paralleling the one shown, that is, by extending the plant at right angles to the direction of flow of materials. This same general principle holds for the intermittent plant shown in Figure 20, where possible extensions are shown. It will be clear that in Figure 20 the extensions can be carried on indefinitely without interfering with the original direction of flow of work. An ideal building plan is one arranged in some unit system so that additional units can be added at any time without disturbing the flow of work or the organization.

11. *Application to very large plants.*—The degree to which the general principles that have been discussed in the foregoing sections are applicable to very large plants is interesting and important. In large steel mills the problem of transportation and flow of

material is highly important, and provision for growth is equally important. At the Gary works of the Indiana Steel Company, for instance, the open hearth buildings are purposely set at an angle with the blast furnaces and finishing mills in order to obtain an arrangement of tracks over which cars can be moved at a high speed, and provision has been made for extension of the plant without disturbing the general plan or flow of work. In other very large plants this care may not be necessary. The plant of the General Electric Company at Schenectady manufactures an immense variety of goods in so many sizes that flow of material thru the plant as a whole is not possible or even desirable. In this great plant the buildings are placed for the most part at right angles to a wide central avenue. The shops are connected by a very complete system of electrically-operated cars, and if a part is to be moved on a car from one shop to another, it makes little difference, economically, what the relation of these shops may be. In fact in considering the very small plant or the very large plant, great care should be exercised not to apply principles of design or organization that represent successful practice in medium sized plants only. There is always danger that general laws do not apply to special cases.

REVIEW

Distinguish between continuous-process industries and intermittent industries. What different demands do they make with respect to plant arrangement?

In arranging an industrial plant what controlling influences would you take into consideration?

How can buildings and machinery be arranged to the best advantage?

How is provision made for expansion?

CHAPTER XVIII

PRACTICAL LIMITATIONS IN APPLYING INDUSTRIAL PRINCIPLES

1. *Advanced methods not always applicable.*—In the foregoing chapters it has been assumed, generally, that the conditions are such that the principles discussed can be applied with an assurance that an economic gain will result. The assumption does not always hold, however, and when a loss is incurred, or when it is found that the principle used does not apply to the conditions, sweeping condemnation is often made of all modern methods. It is highly important to know the limitations of any industrial principle, and it is not always an easy matter to satisfy oneself regarding its applicability. Thus the economic value of division of labor is well known, and long experience has taught men that when they specialize closely they become more expert and more productive. But there are no measured and tabulated results that indicate the relative value of different combinations of divided labor, either for a given product or for many pieces of the same kind.

The idea which underlies planning work in advance as discussed in Chapter VIII is sound, but obviously there are many shops where such planning methods do

not apply, and many others where they would result in a decided loss. In some enterprises it will undoubtedly pay to install elaborate cost systems and there are others where refined stores methods are fully justifiable. In other places, on the other hand, such elaborate methods would be obviously out of place and wasteful. One shop may find that refined standards and careful inspection are essential, while in another shop simple and comparatively inaccurate methods of measurement may suffice. Similar remarks apply to the use of reports and committees, and in fact, to any and all of the machinery of industrial management. The question naturally arises as to how the applicability of these methods can be judged.

2. *When labor-saving machinery is profitable.*— In the matter of labor-saving machinery it is usually possible to make mathematical calculations that will demonstrate fairly conclusively whether a proposed change will be economical, provided always that the quantity of product to be produced is known. The mathematical basis of labor-saving machinery is not, however, so well understood as it might be. A good illustration of this is the problem of making jigs and fixtures for certain lines of product. Where special equipment of this kind is provided, its cost should be considered a legitimate part of the cost of production, and this cost should be recovered as soon as possible by distributing it over the cost of the product in some approved form. There are very few instances where special appliances should be carried as an asset, for

when they have been used for the immediate work for which they were designed they are practically worthless.

Suppose that the labor cost of doing a certain piece of work with hand tools is \$5, and suppose that by making a drilling fixture worth \$60 the labor cost of the operation can be reduced to \$2, thus saving \$3 on each piece. Then the unit cost of any number of pieces n will be $\frac{\$2 \times n + \$60}{n}$. This unit cost will equal the cost by hand or \$5 when $n = 20$ and the tool will just have paid for itself. If 100 pieces are made, the unit cost will be \$2.60 and when 1000 are made, the unit cost will be \$2.06 and the cost of the tool becomes almost negligible. The problem of laying out a set of labor-saving appliances for a given line of product that is to be made in many sizes is a nice mathematical procedure. For the smaller sizes where the numbers to be made are large, a complete and costly equipment will pay; for intermediate sizes a less complete equipment will be economical, while for the larger sizes it will not pay to make special tools of any kind, since the number of each of the larger sizes that are to be made will not justify the expenditure as compared with hand work. There is the modifying consideration, of course, that special tools are sometimes necessary to secure accuracy, but this is not an economical problem in the sense now being discussed.

3. *Costs incurred may exceed costs saved.*—These economic relations between volume of product, unit

cost and the cost of equipment should be carefully noted. It is not always possible to make similar calculations concerning the effect of division of labor with the same degree of accuracy, unless the proposed division of labor is connected closely with labor-saving machinery. We can calculate the output of machines much more accurately than we can that of men. But these economic relations are the most important regulative principles in installing labor-saving management as well as labor-saving machinery. The question of quantity is all-important. No matter how beautiful the theory may be, it is sure to fail if it involves expenditures that are not justified by the quantity to be produced. It is a common criticism of many modern systems of organization that they do not always recognize these limitations. The machinery or organization that may be very effective in mass production may be entirely out of place where the product is less in quantity. And even in the very large establishment it is essential that these limitations be observed. It is not difficult today to find in many large enterprises elaborate equipment and complex organization that are not justified by the work that is being performed by them.

4. *Will workers cooperate?*—The foregoing discussion, furthermore, has assumed for the most part that the principles discussed can be applied in an abstract manner and that men can be made to conform without question to any industrial arrangements. In the earlier days of the modern industrial system this

was true in a large measure—at least it was more true than it is today. The industrial revolution coming suddenly upon the working classes found them totally unprepared to resist any innovations in industry, whether the changes affected them for good or for ill. The conditions of today are vastly different and it does not follow that the workers will acquiesce in any given method that will increase production; in fact, a large portion of those affected may violently oppose it.

The fact that a given innovation will increase production is no longer sufficient reason for its introduction. An ideal factory so far as producing profits is concerned would be one equipped with high-grade machinery but operated by slave labor. This ideal might well have been realized a few hundred years ago, but it does not fit the present age. And as we have grown farther and farther away from these ideals, employers, employes and, more important still, public opinion have become increasingly critical regarding industrial changes. Today, therefore, in all progressive states industry is hedged in and controlled by legislation, public opinion and organized labor.

5. *Attitude of organized labor.*—The influence of organized labor should be especially noted. It is a most natural outgrowth of our modern competitive system and a logical outcome of the evils of the industrial revolution. It cannot be denied that organized labor has committed many unwise acts and many that can in no way be justified. But there is some-

thing to be said on the other side and no one can read the story of the industrial revolution and the degrading conditions that followed the introduction of machine production without seeing the justification for the existence of labor unions. If organized capital now finds itself at times opposed by organized labor, the former is as much to blame for the conditions as is the latter. In connection with this weighty problem there are a few points that every manager should have in mind in introducing any new methods.

There can be no fair-minded objection to the employer using any reasonable methods for finding out what constitutes a fair day's work, and there can be no objection to his contention that he should pay only for a fair day's work. There can be no logical objection to the use of scientific data for selecting men for the work in hand, or in fact for any other industrial purpose that will increase production. Moreover it is a well-established historical fact that an increase in production benefits all classes in the long run. Why, then, does the worker often vigorously oppose these new methods even to the extent of evoking adverse legislation? A short time ago a bill appropriating a large sum of money for the United States Navy carried the provision that none of it should be used for time study work. The antagonism of labor, in general, to any marked innovation in industry is well known.

6. *Labor saving brings change, perhaps suffering.* —It should be remembered that the primary effect of

both labor-saving machinery and labor-saving management is to separate mental labor from manual labor and to extend the principle of division of labor. This, necessarily, results in the disintegration of the trade or calling affected, and the status of the worker is surely changed eventually. In most instances this is a change for the worse for those workers that are immediately affected. Long personal experience and his inherited point of view naturally lead the worker, therefore, to look with suspicion on any new methods. The argument that future generations will be benefitted makes no new thing appeal to men concerned with their own immediate needs.

Furthermore, the majority of people in all walks of life distrust, if they do not actually fear, any innovation that they do not understand and the results of which are not clear to them. All these considerations make the factory worker suspicious of time-study, motion-study and any other measuring devices, for he can see that these are very powerful selective agencies which in the hands of unscrupulous or ignorant persons are capable of working him a great injustice if not a positive injury. The fact that he may receive an added reward because of the new methods is more than offset by the fear of what the future may hold.

7. *Difficulties of introducing changes.*—For these reasons, therefore, the employer does not always find it an easy task to introduce labor-saving methods. Industry is coming more and more to be looked upon

as a means of supporting human existence rather than as a source of private or corporate profit. No doubt the economic principles included in scientific management, so called, will remain as a permanent addition to our philosophy of industrial production. It would appear that no industrial progress can be made without affecting some individual adversely, and when sudden progress is attempted, many workers are invariably sacrificed, industrially, in order that future generations may be benefitted. For this reason labor-saving management will be much slower in coming into use than was its forerunner, labor-saving machinery. Labor-saving machinery was forced upon the industrial worker with or without his consent. It has been an unquestioned blessing to his descendants, but to be so, it tore up by the roots the old industrial methods and the old industrial relations. The inertia of organized labor and of public opinion will greatly retard the adoption of labor-saving management. It will not be enough that it will increase production and profits; it must justify its place in our social economy.

8. *The worker opposes changes.*—These human limitations are of great importance to the industrial manager and should engage his most careful attention. They are much more difficult to handle than the financial and economic limitations that have been discussed in relation to the quantity to be produced. These human limitations lie at the very root of the industrial problem because they spring from the difficulties involved in distributing the fruits of industry.

They find their expression in such matters as wage systems. The Taylor differential wage system has never succeeded in getting a foothold tho the theory on which it is based is perfectly logical. The Halsey premium plan, tho less logical basically perhaps, has been much used because of its conciliatory nature and because it does not contain the element of uncertainty which, as has been noted, is always much feared by the worker.

9. *Instructing the worker.*—In addition to these limitations there are other modifying conditions that the modern employer must take cognizance of. Under the old methods each worker was expected to be self-sufficient so far as his ability to do the required work was concerned. Today it is a well recognized fact that it pays to teach men even in elementary operations. Formerly, also, men were selected for the several functions of any given business by empirical methods that were in many cases of the crudest kind. It has been made clear that the art of selecting men is a difficult one and that careful selection pays good dividends. The old factories were places for housing machinery and for putting men to work; whether they worked in comfort or not was not always considered. At present the wise employer is much interested in the working conditions of his men. He has found that men work better when they are well cared for.

10. *Influence of public opinion.*—For these and other reasons the status of the worker is rapidly as-

suming a new appearance in the eyes of both the employer and the public. Industrial legislation on the part of the latter long ago began to institute safeguards that protect the worker in a large measure against many of the evils of modern industry. Governmental regulation of industry in a detailed manner is now an established principle.

The progressive employer on the other hand is viewing the worker from two new standpoints. The first has to do with the worker as purely a producer; the second has to do with him as a fellow being. The two succeeding chapters will discuss briefly these modern movements.

REVIEW

Why are abstract industrial principles not universally applied?

How is it possible to figure out mathematically whether or not it will be profitable to instal new labor-saving machinery?

Discuss the effects of the introduction of labor-saving machinery and labor-saving management on the working classes.

What is the general attitude of the laborer toward industrial innovations in machinery and methods?

State the difficulties which attend the introduction of changes in plant management.

How can the workers be brought to cooperate?

CHAPTER XIX

PROBLEMS OF EMPLOYMENT

1. *The problem in general.*—Until a comparatively short time ago there could be found in many parts of New England small factory towns where the same families of employers and employes had carried on industries for several succeeding generations. Each and every individual of the community was well known and his abilities and short-comings were public property. Industry, furthermore, was broad and general and each worker, in the skilled trades at least, was expected to perform many functions in a satisfactory manner. The problem of employment was not a difficult one since practically all the workers were known men. Where strangers were to be employed, the opinion and judgment of the foreman was all that was found necessary.

Modern methods have greatly changed conditions, and such factory towns as those described are now the exception. The increased size of factories, the increased facilities for migration, the influx of alien labor and other causes have made a wide gap between employer and employe, while the requirements of modern industry have become increasingly narrow and specialized. At the same time many new lines of in-

dustry have come into existence. The problems of inducting men and women into the industrial positions where they will fit and of securing permanency in the working force are no longer simple problems; in fact they present one of the most difficult and at the same time one of the most important phases of modern industry.

2. *Labor turnover.*—One of the most marked results of these changed conditions is the shifting character of the personnel of most factories. Mr. Magnus W. Alexander of the General Electric Company has made a most interesting and important investigation of this matter, his report covering the experiences of twelve large factories which gave employment to 37,274 employes at the beginning of the year 1912 and 43,971 at the end of that year. The net increase for the year was therefore 6,697, but during that period 42,571 people were hired, and as a consequence 35,874 people must have been dropped from the employment rolls during the same period for one reason or another. These factories were fairly representative in character and size, the products being large steam engines, electrical apparatus, automobiles, and fine tools and instruments. The smallest factory employed about 300 people while the largest had more than 10,000 employes on its pay roll.

In these twelve factories it was found that 72.8 per cent of the employes engaged during the year had not worked in these factories before, while 27.2 per cent had worked in these factories at some previous time.

As a corroboration of this statement it was found by other investigators that in a certain large carpet factory near Philadelphia, 75 per cent of the employes had been in the employ less than one year, nine per cent from one to two years, five per cent from two to three years, four per cent from three to four years, three per cent from four to five years and only four per cent of the employes had been in the employ more than five years. While this last example may not represent average conditions, it is true that this state of affairs and that reported by Mr. Alexander are undoubtedly only too common and this constant shifting of workers is a tremendous source of industrial loss. The term "labor-turnover" has been given to the ratio of the number of hirings per year to the total number employed. Thus if the average number of employes for the year is one thousand and one thousand new men are hired, and as many are 'fired," to use a shop term, the labor turnover would be one hundred per cent.

3. *The causes of labor turnover.*—There are many reasons, of course, why men are discharged or quit their jobs, but it will be obvious that these causes may be divided into those that are due to some lack or misfortune on the part of the employe and those that are due to some remissness or misfortune on the part of the employer. On the part of the worker will be found such reasons as incompetence, insubordination, drunkenness, laziness, a general roving spirit which makes it difficult to stay long in any one place, and

lastly those misfortunes over which the worker has little or no control, such as accidents, sickness or death.

On the employer's part may be found such causes as low wages, bad working conditions, failure to protect the worker properly against accident, a bad attitude on the part of foremen and superintendents toward the employes, thus preventing the growth of interest and friendly feeling, unfairness in making promotions and inefficient management in general. To these should be added such factors as the fluctuating character of some industries and the seasonable demand for certain products for which neither employer nor employe is to blame. Such investigations as have been made go to show that a large percentage of the trouble is due to incompetence on the part of the workers, and this in turn is due to faulty methods of selecting employes and to lack of proper facilities to train them for the work in hand, when it may be special in character and differing from that in other factories or other lines of work. It should be remembered that industry of all kinds has become very complex and highly specialized so that a worker well trained in one line may find himself entirely out of place in an industry that, apparently, differs but little from that with which he is familiar. This great outstanding fact should be kept in mind, namely, that in all industries it is customary to "hire and fire" many more men in any given time than are regularly employed.

4. *Cost of labor turnover.*—While it is generally

conceded that hiring and training new workmen is a source of considerable expense, it is not generally known how great this expense may be, nor are the detail losses which make up the total always fully understood. These detail losses may be summarized as follows:—interviewing new men; medical examination, if one is required; investigating applicants and sources of labor supply; instructing new men regarding their specific duties and regarding general factory rules and regulations; wear and breakage of machines and tools by inefficient or unskilled men; reduction in production due to unfamiliarity of new men with machines and surroundings; cost of work spoiled by new and perhaps inexperienced men and similar causes.

It will be clear that the total cost will vary with the class of work and character of employes, and it is not an easy matter to get mathematical data that are reliable or conclusive, but such as have been obtained are somewhat startling. Mr. Alexander states that the average estimate that he obtained by inquiry of a number of managers was between fifty and one hundred dollars for each new employe. In his investigation he has classified the employes considered into five classes as follows:—A, highly skilled mechanics; B, mechanics of lesser skill who can be trained in two or three years; C, operators and piece workers who require only a few months to train; D, unskilled laborers and helpers; E, clerical help in shops and office. Using this classification Mr. Alexander gives the fol-

lowing estimates of the cost of hiring new men and of rehiring old employes:

COST OF HIRING

Group	Hiring	Instruction	Wear and breakage	Reduced production	Spoiled work	Total cost	Cost of rehiring
A	$0.50	$7.50	$10.00	$20.00	$10.00	$48.00	$10.00
B	.50	15.00	10.00	18.00	15.00	58.50	20.00
C	.50	20.00	10.00	33.00	10.00	73.50	35.00
D	.50	2.00	1.00	5.00	....	8.50	5.00
E	.50	7.50	1.00	20.00	....	29.00	10.00

Mr. J. D. Hackett of Clapp, Widdemer and Hackett, industrial counsellors, to whom the author is indebted for considerable data on this interesting topic, has made some careful studies of the cost of hiring and has arrived at results that in general corroborate Mr. Alexander's estimates. Mr. Hackett's totals corresponding to those given above are: $45.25; $67.75; $56.75; $13.75 and $37.75; and for the cost of rehiring his corresponding estimates are: $22.50; $35.00; $25.00; $6.00; and $15.00. The important question concerning these investigations and results is not their relative accuracy so much as the startling size of these totals as given by all who have investigated the problem. Mr. Hackett has also pointed out that the cost of hiring a man is relatively great or small depending upon the length of time he stays in the employ. In this respect this cost is like any other preliminary expense. It may be worth while to spend some money in securing good employes if such an expenditure results in permanency and stability of the working force.

5. *Methods of reducing turnover.*—The foregoing discussion naturally suggests ways and means of reducing the labor turnover. Among the most important remedies are:

(a) Improved methods of hiring and discharging men
(b) Facilities for training new men for their duties
(c) Reducing fluctuations in volume of work
(d) Offering financial inducements
(e) Medical supervision and care to safeguard the employe against sickness and accident
(f) A human interest in the employe with a view to securing his interest and to making him contented.

It has already been demonstrated that remedies such as these are helpful in reducing the labor turnover. The first four will be briefly discussed in this chapter while the last two are discussed in the succeeding chapter.

6. *The modern employment department.*—It is generally conceded that it is good administrative policy to have as few functions as possible performed by any one individual. The separation of functions and the development of experts for each duty is in strict accord with the theory of division of labor, and the problem of hiring men is no exception to this rule. In small shops where the employes are few, this work must, for obvious reasons, be done by the foreman or

superintendent, but in plants employing 500 or more employes this work should be in the hands of one man who should devote all his time to the problems of employment. Many modern plants are now handling these problems in this manner and the centralized employment office under a special employment manager is rapidly becoming the rule rather than the exception.

The primary duties of the employment manager are to find and develop the sources of labor supply; to examine applicants for positions and to select new employes whose qualifications will fit the needs of the factory; to study and classify these needs and reduce them to written statements so that applicants can be fully informed in advance of what will be expected of them in the factory.

The second duty of the employment manager in a well managed shop is to make a study of plant conditions as affecting the employes. Such a study will include the methods by which men are introduced to their work. This item may be of broad significance and may include preliminary preparation of an educational character. If an apprenticeship system is in operation or if extension school methods are in use, the employment manager should be in close touch with if not in actual control of these functions. He should also study carefully the conditions under which the men work with a view to discovering any conditions that work adversely to a spirit of cooperation between the men and the management. This study should

include the treatment men receive from the foremen, hearing complaints and grievances, methods of promotion, transfers from one department to another, adjustment of wage rates and, most particularly, the employment manager should examine every case of discharge or other cause for leaving the employ. He should also study the causes and effects of absences.

It may be objected that many of these duties are now and should remain in the hands of the foremen, and many foremen will object to having these functions taken from them. Most of the functionalized positions in modern management have had to make their place against these very same arguments. The trained designer, the toolmaker, the storekeeper, the cost-finder and others that are now considered essential to good organization were called into being by the same demands for more refined methods that are now making it evident that low labor turnover and more economical production can be secured by a more intelligent study of the problems of employment. Many concerns have already recognized that this problem is a far-reaching one and have given the employment manager wide powers.

A third function of the employment manager may be the supervision of welfare work, so-called, including certain features of plant betterment such as medical supervision and accident prevention.

7. *Sources of labor supply.*—Few employers have any idea of the sources of their labor supply, the great

majority depending upon personal applications, selecting those who may appear competent. While such methods may suffice for small shops, large works should have definite and well known sources of labor supply. This method can, however, be supplemented by careful inquiry among reliable employes. If often occurs that workmen know of friends or others who would make desirable employes. Obviously such inquiries should be made only of those employes that are trustworthy and satisfactory from the standpoint of labor questions in general.

Another source of supply is found in employment agencies. Agencies engaged in supplying highly trained men, such as engineers and teachers, are usually useful and reliable. Those supplying cheaper labor are usually not so reliable, tho they are often useful in furnishing large numbers of workers at short notice as is sometimes needed in railroad work. State and municipal labor bureaus have not been very successful as a rule.

Advertising is, of course, simply a method of increasing the number of personal applications. It is much used and with good success for obtaining men for the higher positions where the applicant is expected to furnish unquestionable records and credentials. It may also be used effectively where an immediate increase of labor is essential and where quality cannot be too closely considered. It is not a good method for securing a permanent supply of well-trained, reliable men.

If the plant is large enough to afford such a plan, the best method of securing good labor is thru a good apprenticeship system in connection with educational methods. Industrial education of some kind or degree is rapidly becoming an essential requirement for factory workers. In many places satisfactory cooperative arrangements can be made with local public or private schools so that a constant stream of well-trained boys and girls are passing into the industry. Many large plants have auxiliary school-shops organized for this special purpose and cooperative school and shop methods are becoming more common daily. No large plant can afford to neglect this method, for in all probability it is the ultimate answer to the problem, and the only solid foundation on which an industrial population can be sustained. The Santa Fe Railroad has had an excellent apprenticeship school in operation since 1907, and since that time 884 apprentices have been graduated. Of this number 632 or 71 per cent were still in the service of the road last year, and 18 per cent have been promoted to positions of responsibility. Many similar cases could be cited and in the author's opinion this method is the most promising one in reducing labor turnover.

8. *Empirical methods of selecting employes.*— Whatever means are employed to get in touch with sources of labor supply, some method of selecting those that are to be hired must be adopted. For the most part these methods of selection are still empirical, reliance being placed on the personal judgment

of the foreman, superintendent or employment manager, supplemented perhaps, by recommendations of some kind. The value of the latter is problematical, except as concerns personal character, unless the work for which the worker is engaged happens to be very much like that to which he has been accustomed.

There is no doubt that personal judgment based on long experience is not to be dismissed lightly, and the writer has seen some magnificent organizations of men built up solely on the keen judgment and insight into human nature possessed by a single superintendent. This was easier to do, however, when work was more general in character, and when the workmen employed were of the all-around type, now rapidly disappearing. In hiring such men the specifications of the work to be done were covered by the experience and skill of all good workmen of the class required, and selection became largely a matter of judging personal characteristics, a faculty with which some men are naturally gifted and hence become highly efficient in selecting reliable workers.

While the need of judgment and insight into human nature still remains the most important feature of employment work, the conditions of industry have changed and any employment manager who is to hire men for any large industry must recognize the fact that to do so successfully he must have accurate specifications of the work to be performed and that he must match the experience of the worker to these specifications or provide some method of preliminary

training before the worker will fit into the vacancy which is to be filled. For these reasons many advanced managers have adopted methods similar to those in use in colleges and governmental activities, namely to eliminate, as far as possible, the employment of workers that are sure to be misfits. It may be of value to review briefly some of these advanced, yet perfectly logical, methods.

9. *Physical fitness.*—Every progressive factory of any magnitude is now equipped with a resident physician and hospital facilities for caring for the accidents and sickness occurring to those employed. It is even more logical to examine the worker physically at the time of engagement and many employers are now requiring such an examination. Mr. H. L. Gardner, Employment Manager for Cheyney Brothers, reports that in a single month 449 applicants were thus examined, and that 597 cases of accident or disease among those already employed were treated. Of the 449 applicants 41 were rejected because of heart disease, tuberculosis or other physical weaknesses which rendered them unfit for the work in hand. Of those selected and employed, 137 were placed at certain tasks only, their physical condition not permitting them to assume more laborious duties. The importance of this last item should not be overlooked. Physical examination should not be used as a means of excluding all but the very best, but should be used as a basis of classification. Obviously, it is a dangerous thing to place a man with a bad heart in charge of

an overhead travelling crane, or a man with bad eyesight in charge of a yard engine. Physical examination at engagement will, no doubt, do much to obtain a better classification of the force and also will serve as a valuable basis for keeping the force in prime physical condition. A purchaser of cattle or horses would take all these precautions, yet it is difficult to convince some men of the economic value of these common-sense proceedings.

10. *Specifications of work to be performed.*—There still remains much work that is simple to describe and of which the general characteristics are easy to understand. For the most part, however, we know very little about the exact requirements of factory work, and little or nothing has been done in classifying operations with reference to the personal attributes of the worker who is to perform the task. The work of Taylor, Gantt, Gilbreth and others referred to in Chapters VIII and IX gives ample proof of this statement. It was comparatively easy to match the all-around ability of the old mechanic against the general character of industry of a few decades ago. But extreme division of labor by reducing industrial operations to a few functions has created a need for workers with certain characteristics. Thus one job may require dexterity, another quickness of vision, another concentration, or any combination of these personal attributes. Clearly it is not an economic policy to employ men for duties for which their personal characteristics and training do not fit them, but this can-

not be avoided unless the requirements of the positions to be filled are clearly definable. It is helpful both for the employment manager and for the foremen to endeavor to specify in writing just what the requirements of every position are before hiring a man to fill the place.

11. *Mechanical tests.*—It is a well established fact that man's natural bodily characteristics fit him better for one kind of physical activity than for others. Thus oarsmen, sprinters, baseball players and other athletes have clearly distinguishable bodily characteristics which skilled trainers look for in selecting such men. In a more detailed manner each worker's arms and fingers fit him naturally for certain kinds of work in preference to others. The experimental psychologist long ago developed methods for testing the human machine and measuring its possibilities, but as yet these methods have not come into common use in selecting men. These psychological and physiological tests include the measurement of speed and dexterity of both hands, of range of eyesight, ability to comprehend verbal instructions, power of imitation, power of concentration, mathematical speed, quickness of thought, etc. A discussion of these methods is beyond the limitations of this volume, but the interested reader will find in the *Industrial Management Magazine* for 1916–17 three very instructive articles by William F. Kemble which discuss some simple mechanical methods for testing the most common manual and mental requisites that will amply

repay reading. Not a few large corporations are now applying such mechanical or mental tests to applicants for positions.

12. *Psychological tests.*—The work of the experimental psychologist is slowly developing a more scientific basis for classifying men than we have hitherto possessed. Laboratory methods are now developed that will measure all manner of human attributes including such very refined functions as the mental processes themselves. The best known worker in this field was the late Professor Hugo Munsterberg whose writings on this subject have been noteworthy. In a similar manner Dr. Katherine Blackford has advanced the idea that physical appearances can be used as a basis of classification for industrial fitness. She has undertaken to show that a man is not short or tall, blonde or brunette by accident, and that the shape of his nose and the outline of his face have all evolved thru definite experiences of his ancestors. She has also applied these theories to the selection of men for the industries in a practical manner.

While there can be no question that the background of these philosophies is sound, it is questionable as yet whether they have been advanced to the stage where they can be applied intelligently to the problems of industrial selection. It should be remembered that this is a most difficult and elusive problem and it will probably be some time before we shall be able to lay aside personal judgment and measure men and women as we now measure inert material. Nevertheless, this

phase of industrial progress should be carefully studied by the progressive manager.

13. *Educating the worker.*—No matter how small the part which the worker is to perform, care should be taken to see that he thoroly understands his work. This is particularly true in starting a new employe at work. All difficulties should be removed from his path as far as possible and every precaution taken to make him feel at home and to familiarize him with his new surroundings. In work of special character, this preliminary instruction may be truly educational in form and as has been stated, many companies have found it a good investment to establish schools of one kind or another to promote the progress of their employes in the work of the factory.

Aside from these general educational efforts, however, it will be found that it pays to instruct the worker in the particular work in which he is engaged. Mr. H. L. Gantt has made a real contribution to this subject in his writings on task and bonus work. He found that great increases could be made in the output of workers who were, in the beginning, only mediocre performers, by careful and systematic instruction in the details of the operations to be performed. If such instruction leads to higher output and consequent higher pay, one of the first causes of labor turnover is removed. Obviously this is a better way of securing a permanent force of men than the old method of "hiring and firing" and retaining only those who happen to qualify.

The broad principle that it pays to educate workmen in matters pertaining to the factory is now widely recognized and many large industrial concerns are giving careful attention to this phase of management. As this form of managerial activity is closely connected with employes' service, further discussion of it will be deferred to the next chapter.

14. *Transfers and discharge.*—In factories involving a variety of work and consisting of many departments, it may occur that a worker may not be satisfactory in one department, but may do very well when transferred to another. In progressive shops, therefore, when an employment manager is installed, the individual foreman can discharge a man only from his own department, and the employment manager has the privilege of placing him elsewhere if he so desires. In this connection it should be noted that there is much to be desired in many foremen. No one man should be picked with such care as the foreman, for he alone represents the company to the worker. To get work out of men and yet keep their friendship and loyalty to the organization is a fine art, and every manager will do well to see that his foremen maintain the right attitude toward the workmen. Arrogant, blustering ways, unfair methods, and above all unjust discharge do not pay dividends and they belong, furthermore, to an age that is rapidly passing away. If no employment manager is employed, the superintendent should know the full reasons for every discharge. It should be difficult for a good worker to get employment in a

good plant, but once employed it should be as difficult for a rival concern to induce him to leave, and to this end he should be protected against unjust and discourteous treatment.

15. *Reducing fluctuations in output.*—Many large factories make what are known as seasonal goods. Thus, the market for arc lamps is active in the fall and hence the busy manufacturing season is during the summer. Straw hats must be made during the winter to meet a sudden and large demand in the spring. Unless such fluctuations in product are counterbalanced by other goods, the labor force must fluctuate with the volume of work. Some of the trades, as bricklaying, fluctuate not only because of the season but because of the unavoidable irregularity in building operations.

In many industries this is a difficult problem to combat, yet it is one of the most serious causes of labor turnover in many shops. Unemployment is one of the most dreaded of all ills to which the worker is exposed. He most naturally, therefore, prefers a shop where employment is steady, and no doubt many industries would be better off financially if production were equalized over the year, even tho this should involve a greater interest on investment. It would be more than offset by the reduced cost of labor.

16. *Fatigue.*—One of the most interesting and important discoveries that has come out of modern industrial investigations is the effect of systematic rest periods. Under the old and still much-used methods,

the common idea was to keep a man as busy as possible during the entire working period for which he was engaged. It now appears that he will do more and better work if given periodic rests.

All are familiar with the phenomena of fatigue. In beginning work there is a period during which effort is not only easy, but agreeable, and the rate of production increases. Then follows a period during which conditions are uniform, succeeded in turn by a decline in interest and pleasure in production, straining begins to be felt and finally, if the effort is continued, pain appears. During this latter period the worker must put forth his will power to continue at the task, "working on his nerve" as we say, and at last if the effort is still continued, it becomes unbearable and complete exhaustion takes place.

Physical or mental effort of any kind results in the breaking down of tissues which creates certain poisons in the blood, giving rise thereby to the phenomena described. If the effort is slow, the system reacts fast enough to dispose of these waste products as soon as they are formed, but it cannot perform this cleansing action against great and continued effort. Recovery from moderate fatigue is rapid, but the recovery from great effort is slow, and as the worker gets older it is less and less complete. It is a well known fact that violent exertion on the part of old people is dangerous. Fatigue within the "elastic limit," however, is wholesome for any one and good health cannot be maintained without some bodily effort.

17. *Differences between old and new conditions.*— It should be remembered also that change of work is relative rest, and under the old method, where the worker performed several different tasks daily, recovery from one task took place to a certain extent while performing another. Under such conditions the rest obtained during the hours when he was not employed was sufficient for his recovery. Thus farm laborers work long hours daily during a large part of the year, yet the short periods of daily rest supplemented by the Sunday rest seem amply sufficient for physical recovery.

Under modern industrial conditions, however, where men are compelled to work at one machine or, worse still, where the work is of a repetitive character involving little or no change of mental or bodily exertion, common experience indicates that the rest periods should be more frequent and more definite than under the old conditions of general work. The effect of monotonous labor has long been a matter of study and psychologists have demonstrated fully the harmful effects of such labor, if carried to an extreme. Efforts have been made, also, to relieve the monotony of repetitive labor by introducing other distracting influences. Thus in cigar making, paid readers have been employed with success to relieve the monotony of this repetitive occupation. There can be little doubt that the practice of "soldiering," or pretending to work while really accomplishing nothing, has been fostered to a large extent by lack of proper

and definite rest periods. Aside, therefore, from all humane considerations of the matter, this subject is one of considerable economic importance.

18. *Length of rest periods.*—We have little or no data as yet that can be used as a guide in fixing rest periods. Experimental psychologists have done considerable experimental work, but so far their results have been expressed in very general statements. It is well known, also, that fatigue is a factor of the speed of performance, for we exhaust ourselves much more by doing a given task quickly than by doing it slowly. This follows naturally, of course, from the general theory of fatigue that has been discussed. These relations are not simple ones, however, and an immense amount of experimental work in actual productive processes must be performed before we shall have data that will enable us to predict the correct proportion of work and rest in a new performance.

Advocates of scientific management, so called, have made some interesting and convincing experiments on a fairly large scale and have demonstrated that production is greatly increased by the introduction of definite rest periods. Mr. F. W. Taylor, himself, proved that a first-class laborer handling pig iron, each pig weighing 92 pounds, should be under load only 43 per cent of the day and must be entirely free from load 57 per cent of the day. He stated, furthermore, that as the load is made lighter, the percentage of the day under which the man can carry the load can be increased. Thus, if the workman is carrying

a load of 46 pounds he can be under load 58 per cent of the day, and if the load is made light enough he can carry it practically all day long. Other experimenters have found similar results, and the general principles of the economy of fixed rest periods seem to be well established. It will take some time, however, to obtain sufficient data to formulate practical rules for the guidance of industrial workers in general.

However, the matter is one that should engage the attention of every manager, and there are many industries where it would be economical, no doubt, to establish more frequent rest periods than those now in use even tho such periods are fixed empirically. The general theory of fatigue, furthermore, indicates that a careful study of the worker's surroundings and implements may often result in greatly increasing his output by decreasing the fatigue caused by distracting influences or wasted efforts.

REVIEW

What is meant by labor turnover? How do you figure the percentage of turnover in factory equipment?

Why is a high percentage of labor turnover a bad condition?

What remedies are progressive managers using to reduce this percentage?

State the different sources of labor supply. What is the best system for insuring a continuous supply of skilled workers?

How do employment managers seek to get the right man for the job? What tests are being used to insure the safety of the new employe and the fellow employes and at the same time tend to reduce the cost of labor turnover to the employer?

What is the nature of fatigue and what bearing has it upon output?

CHAPTER XX

EMPLOYES' SERVICE

1. *Causes and origin.*—The industrial revolution which separated the industrial worker from the ownership of the tools of industry made him almost entirely dependent upon the employing class for his means of subsistence. Unfortunately for him the employing class of a century ago held ideals vastly different from those of the progressive employer of today, and as a consequence the workers in the industries immediately affected quickly found themselves in deplorable surroundings. As the uneducated employer of the industrial revolution, with his narrow money-grubbing view, gave way to the intelligent, educated employer of the present, two distinct principles or points of view developed in our social and political creed. The first is the idea that the public has a right to regulate the manner in which industry shall be conducted in so far as industry affects matters of common interest. This tenet is the basis of industrial legislation with which we are now experimenting and the limitations of which cannot be seen at the present time. The second idea is that every employer owes a duty to his employe over and above that required by law and as expressed in

the wage agreement; that he is in a large sense his brother's keeper and that his responsibility is a true stewardship. From this last has grown the movement known most commonly as "factory welfare work" or "betterment work." These terms, however, have become identified somewhat with certain efforts along this line that savor strongly of philanthropy, paternalism or reform work incident to the early stages of the movement. Many of these efforts were dismal failures but they have been useful in showing the true nature of successful work along this line which savors less of philanthropy and more of real service. The name "employes' service" is, therefore, coming rapidly into use as indicating more clearly the true scope of this work. Industrial legislation and employe's service, as will be seen, may be and usually are closely connected, tho this is not always obvious.

2. *The work of Robert Owen.*—So far as it is possible to give credit to any individual for originating this movement, such credit must go to Robert Owen, who in 1800 at the age of 28 became managing owner of the New Lanark Mills, about twenty miles from Glasgow. The village contained about 1300 people in families and between 400 and 500 pauper children between five and ten years of age. These children were "parish apprentices," that is, children from the poor houses who had been placed in the mills as loom or spinning machine tenders under agreement with the pauper authorities. Practically the only law

governing the mill and the village was the will of the owner or manager.

Of these people Owen says they "lived almost without control in habits of vice, poverty, idleness, debt, and destitution," and it was these conditions that he set himself to removing. His reforms included improved sanitation in the factory and in the village, the establishment of a library and schools, of recreative features and of methods of supplying the necessities of life at low rates and in such a manner that the workman would not be cheated. He abolished the saloons, reduced the working day from thirteen and fourteen hours to ten hours daily and, in fact, anticipated every form of this activity that has since been attempted.

This work he carried on thru good times and bad times, at one period paying full wages for four months while the mills were idle, at a cost of $35,000. At first he had great difficulty in convincing the workers that he was in earnest; but once he obtained their confidence, he succeeded in building up a most remarkable model village, and in spite of the great expenditures for these activities the business prospered and paid handsome profits.

3. *Modern efforts.*—Owen was a reformer ahead of his time and his example was not followed widely. His methods, furthermore, are not applicable in their entirety today under vastly changed conditions. But his work will always remain the great pioneer effort, and the spirit which he breathed into this effort will

long inspire men to inquire of themselves what their duties are toward their fellow men. In recent years this movement has taken on great life and force and may be recognized as marking the passing of industry from the control of men whose main purpose is to make profits, to the control of a more intelligent, more highly educated and more humane class of employers. The scope of this movement and its probable place in industrial management can be best judged after a brief survey of some of the most important features of the work as it appears today.

4. *Definition of employes' service.*—It would be difficult to list and impossible to discuss within the limits of this book the many forms that welfare work, so-called, has taken. Almost every phase of home and factory life has been used at one time or another to serve as a basis for this work. The most important features of the movement as it stands today may be classified, however, under six headings, namely:—

(1) Conserving the health of the working force
(2) Factory hygiene and personal comfort
(3) Accident prevention and relief
(4) Educational efforts
(5) Financial aid
(6) Recreation work.

A brief discussion of some of the more important features of each group may make the content and limitations clearer.

5. *Health conservation.*—In no one feature of fac-

tory administration has there been such a change in point of view as in this field. The manager of a factory a few years ago would take every precaution to protect his horses against disease, but the health of the human worker was the worker's own business. The progressive employer of today, however, knows that it pays to look after the health of his employes. Sick men are not efficient workers. Dr. Otto P. Gier, Medical Director of the Cincinnati Milling Machine Company, says of this: "The loss in wages to the workers on account of preventable but unprevented diseases runs annually into the billion dollar mark. The accompanying loss to the employers must surely be twice that amount when we remember what a part bad health plays in efficiency." Many plants therefore now have a resident physician and a well equipped dispensary. Such an equipment will most commonly first justify itself and make a place for itself in the factory as a measure for first aid and accident relief. But, if this activity is in charge of the proper kind of physician who can win the confidence of the employes, it will in a short time become a center from which will radiate advice and counsel concerning all manner of personal ailments, and the resident doctor will become a confidant and personal advisor to the entire force. The value of such a department in hiring men has been discussed, but its greatest good will be with those already in the employ and in following up those who have been examined at engagement. Such a department is of great value

also in looking after the general sanitation of the plant. The objection may be raised that a small plant cannot afford such a department, and this is true. Dr. Gier thinks that any company employing 750 men can afford a resident physician and a dispensary, and he suggests that smaller concerns may accomplish much by cooperative methods.

The extension of medical service to the families of employes borders on philanthropy or paternalism and is, therefore, a questionable practice. It is true, of course, that an able shop physician with social tendencies may do much in a personal way among the families of the workers. But the systematic supervision of such families by the shop physician with the aid of a visiting nurse, as is being done in some places, may result in more harm than good. In any case this phase of service must be approached with caution and it may be better to handle it as a community problem, as is being done in some places.

6. *Hygiene and comfort.*—The recognition of the value of conserving the health of the employe carries with it a new view concerning his surroundings and equipment. The original idea of a factory was a place to house machinery and the fact that human beings had to spend a large part of their life in these buildings was given little consideration. Who does not remember the machine shops of a few years ago, dingy, dark and cold, with unspeakable toilet arrangements and general lack of sanitation? Many such factories still exist, unfortunately, but they are rap-

idly becoming the exception. It is a well recognized principle that it pays to provide heat, light and ventilation and that a worker produces more when his bodily needs are well cared for.

In all progressive states the law fixes a minimum of excellence for sanitary arrangements, and in such states all factory workers are protected against gross negligence on the part of factory owners. Such regulations are in a large degree the result of the efforts of reformers and progressive factory owners who find in the law the only force that will compel universal recognition of what is just and right. In fact, welfare work in general has always been a forerunner of protective legislation, and the voluntary reform work of one period is often the legal regulation of a later time.

But there is still much that can be done in this particular field over and above that required by law; and most of these efforts will pay dividends. Space will permit only a brief discussion of a few of the items of this important field, namely, ventilation, washing and dressing facilities, toilet facilities, lighting equipment, individual equipment and housing.

7. *Ventilation.*—All new modern plants are fully equipped with adequate devices of some kind for insuring a plentiful supply of pure air, and the principles of ventilation are well understood. But there still remain many old factories built years ago, before attention had been focused on this need, where the installation of a good system of ventilation would add

not only to the comfort of the workers but to the dividends of the company. This is especially true where dust or obnoxious vapors are prevalent, as in grinding and buffing rooms and plating operations. Well-developed apparatus for this purpose is now on the market and there is no excuse for a foul or dusty atmosphere in the factory. Such conditions are conducive to ill health, ill-temper and general inefficiency.

8. *Washing and dressing facilities.*—In these days when good lavatory equipment costs so little, comparatively, there is no excuse for not providing proper washing and dressing facilities. Every argument is in favor of such equipment. Dr. Gier says that the worker who leaves the plant in his working clothes (often saturated with sweat) is 80 per cent more liable to respiratory diseases than the worker who has washed and changed his clothes. Aside from this, nothing adds so much to a man's dignity and helps to keep up pride in his calling as to appear on the street clean and neatly dressed. If it is desired, however, to encourage workers to wash and change their clothes, adequate provision must be made to avoid crowding at quitting time.

Detailed description and specification of such equipment are beyond the space available here, but such information can be had from any good industrial architect. Care should be taken, however, to keep the equipment as simple as possible consistent with efficiency. The worker will place small value on elab-

orate bathing facilities in the factory if his scanty pay forbids a tin bath tub for his family.

9. *Toilet facilities.*—There is no excuse in this age for not installing modern toilets of at least fair quality. At least one toilet should be provided for every twenty persons. Two methods are in use for installing toilets. In the first they are grouped in one large room or in rooms, depending on the size of the plant. In the second method they are scattered thru the plant to lessen the distance travelled by the workmen. The first method, while a little more wasteful of the time of the worker, admits of more careful supervision, hence of greater cleanliness.

In any case these facilities should be housed in heated rooms, properly ventilated; and they should be kept clean. The practice of installing them in cold out-buildings is neither humane nor economical. Each toilet should have a screen door. The exposed toilet is a barbarous crudity that will soon be prohibited by law. Urinals should be distributed thruout the plant for economy's sake. Drinking water should be supplied by bubblers and the common drinking cup should be abolished.

10. *Lighting.*—Good lighting, aside from its value in preventing accidents, is an economic measure of great importance. In these days of improved electric and gas lighting there is no excuse for the use of candles as one still sees in old-fashioned plants. Modern lighting installations aim to reduce all eye strain by avoiding direct exposure of the lamp, par-

ticularly if it be very bright. Eye strain increases accident hazard, and proper shading pays.

11. *Individual equipment.*—Good management will insist that the immediate surroundings and the personal equipment of the worker are such as to make him comfortable and efficient. Some companies have gone so far as to furnish the working tools that tradition has made the personal property of the worker, so as to insure first-class working equipment. Economy and human interest go still farther and insure convenient working conditions. If a chair or stool with a back will increase the worker's output, why not give it to him? If a lever is poorly placed so as to be the cause of extra exertion, why not change it?

Such painstaking management will also provide proper lunch room facilities where they are needed. The cold lunch eaten at the machine or bench is not conducive to best work, but is conducive to intemperance. Clean, well-warmed lunch rooms are an economy, and, if needed, provision should be made whereby the worker can obtain hot coffee or tea if he so desires. The distance to which it will pay to go in furnishing mid-day meals usually depends on local conditions. But in any case, no appearance of paternalism should be mixed with these efforts. Good, well-cooked food, furnished at cost, is always acceptable to workers, and many very successful lunch rooms are now in operation. Ample time to eat the mid-day meal will greatly increase the worker's afternoon performance and help to ward off digestive troubles.

12. *Housing.*—The problem of proper housing for factory employes has always been a difficult one. Who is not familiar with the long rows of ugly tenements to be seen in so many New England towns? If good clothes help to keep a man's self-respect and make him a better worker, an attractive home is even more effective. Modern management, therefore, follows the man after he leaves the factory and tries to house him and his family in proper manner. In large cities little can be done, individually, to assist in this problem, but concerted action can produce wonders in clearing up unhealthy tenements and providing good homes. A city cannot engage in any more remunerative or more humane work. In small towns, or in the country, the individual employer can do much in this direction. There has been too much tendency for factory owners to look upon the company-owned houses as simply sources of revenue. In many cases the company can afford to rent houses at cost and still get an indirect gain, out of all proportion to the investment, in the character and quality of labor that will be attracted. Efforts to help workmen to own their own homes will be treated elsewhere.

13. *Accident prevention.*—In no phase of industrial philosophy has there been such a quickening of our conscience as in the matter of accidents. The old philosophy assumed that the worker was sufficiently skilled or careful to look out for himself, and if he was injured because of negligence on his part or on the part of a fellow worker, the employer was not to

blame. Today, it is commonly held that it is the employer's duty to see that every precaution is taken to prevent accidents of every kind, and that if an accident does occur the owner must assume the financial responsibility. This, in effect, compels each industry to pay for its own losses due to accident instead of turning the incapacitated workers adrift to be a charge upon the general public.

As a result there is an unprecedented interest in accident prevention in which the United States Steel Corporation has led the way in this country, tho some European countries had long before developed such work. The American Museum of Safety was established in New York in 1907 with a view to enlisting public sympathy with this work, and in 1913 the National Safety Council, membership in which is open to all manufacturers engaged in hazardous occupations, was founded. At the last annual meeting of this body, held in the Museum of Safety, over 2000 representatives attended a four days' conference on safety measures.

Accident prevention falls naturally into three activities, namely, designing and installing protective devices; educational propaganda which will make workers more careful of themselves and others; and lastly the collection of data which will show progress and indicate what hazards are most dangerous. In respect to the first item much general good can be done thru the careful designing of buildings, stairs, elevators, etc. As regards the protection of machines

there are now on the market all manner of protective devices and much thought is being given to this phase of the matter.

Mr. Arthur H. Young, Director of the American Museum of Safety, estimates, however, that not over 25 per cent of the accidents that occur are preventable by mechanical safeguards, and reasons correctly therefrom that the greatest hope lies in educational propaganda which will awaken personal interest in safety. A most interesting advertising campaign has, therefore, been inaugurated, employing shop bulletins, cartoons, diagrams and pictures portraying in a startling and personal manner the need of caution in this mechanical age. For the industrial engineer this work constitutes a new field of wide scope and of immense economic and humane importance.

Statistics already show that this work is effective. The Steel Corporation, for instance, states that from 1907 to 1915, inclusive, its safety measures saved 15,967 employes from death or serious injury as compared with the records of years prior to the introduction of this work. Mr. Young has also published the statements of 22 concerns that have adopted this work. They show an average reduction of accidents of 60 per cent for the group. The logic of this work is perfectly sound. No one questions the economy of conforming to fire insurance rules as the best means of fire protection. The same argument applies to accident prevention, with the added impetus that it is one of the most humane movements ever inaugurated.

A powerful stimulus has been given to accident prevention by workmen's compensation legislation. These laws place the burden of accidents squarely upon the employer. The burden is carried in the form of insurance, and since rates diminish when safeguards are used, a strong pecuniary motive to reduce accidents to the minimum has been introduced.

14. *Educational efforts.*—The interest of the manufacturer in educational problems comes primarily from the decline of the apprenticeship system. Not only have manufacturers pressed the public schools to introduce industrial training that would prepare boys and girls for industry, but many of them have built their own schools for specially preparing boys and girls for their particular field of work. In so far as these schools seek to accomplish this purpose they are clearly justifiable and useful. It should be remembered, however, that the state long ago made general education its own special province and, theoretically at least, it now insists that every boy and girl shall have the foundations of a liberal education. With these two facts in mind, it is possible to judge clearly of the trend of this great movement. A brief discussion of a few shop-operated schools may make these relations clearer.

15. *Apprenticeship schools.*—The modern apprenticeship school usually takes boys and girls after they have completed the requirements of the state, so far at least as age is concerned. In many cases these pupils have not, however, completed the educational

work necessary for good citizenship. Most of these schools, therefore, offer the general branches besides such specific studies as drawing, mathematics, etc. Special text books have been developed for these schools and they will undoubtedly be a large factor in industry in the future.

16. *Continuation schools.*—Continuation schools differ from true apprenticeship schools in that they may or may not have specific industrial or trade training in view. This type of school is usually intended for boys and girls who have dropped out of school at an early age, perhaps because of family finances. Under this plan the pupil works part of the day and studies part of the day, so that he can "earn while he learns." The classes may be held either in the day or in the evening.

An interesting and growing form of this school is known as the cooperative plan. In this plan arrangements are made with the public school system to give the educational side of the work, the company arranging the factory work so that the transition of the students from the shop to the school and back is easy and convenient. Schools on this plan have been worked out on a large scale in Cincinnati and Fitchburg with considerable success. The University of Cincinnati has applied the plan to the education of the engineering students of that institution.

17. *Education for adults—Americanization.*—Besides such educational activities as these, many companies are offering educational advantages to adult

workers. These facilities are of two distinct types. The first is intended to assist adults whose early education has been neglected or foreigners who cannot read or write English or who speak it imperfectly. While some question may be raised as to whether this is a legitimate activity for a manufacturing company to engage in, there is no doubt that it is a highly necessary work. So far as uneducated Americans are concerned, it may be that the better way to attack this problem would be thru community effort outside the factory. The uneducated foreigner, however, is a menace to the industry of this country and must be absorbed quickly. Every agency that can be applied to this problem should be set at work. Mr. Dooley, Director of the Westinghouse Casino School which is, perhaps, the broadest educational activity operated by an industrial concern says: "It is generally recognized today that the welfare of industry as well as of community life demands the Americanization of the foreign born citizen. To meet this demand many boards of public education are conducting evening classes. But to make the thing really effective, industrial managers and their assistants must make plans to absorb these men into the full spirit of American industry and American life."

The second class of school work for adults is intended for those who already possess a fair or even a good education and who wish to make further progress. These efforts may consist of educational courses offered directly under the control of the com-

pany and having reference to its specific problems as, for instance, courses in accounting, salesmanship, store methods, advertising, finance, etc. Or the company may employ outside educational agents. Thus the Modern Business Course, tho designed for individual study, has been used by corporations as a means of educating its employes of higher grades. Educational activities such as these just discussed may be optional on the part of the employe or they may be required by the employer as a prerequisite for promotion.

18. *Education outside the works.*—Many companies not content with educational efforts within the factory have extended their work to the families of the employes. Thus, some companies offer kindergarten classes for the children of employes, and cooking, sewing and millinery classes for the adult women of the factory community. There may be cases where, because of the local conditions, it may be desirable for the company to offer advantages for general education to the children of the employes, but the author believes that, in general, it is far better to conduct all matters of general education as a community matter which it rightly is. As a private citizen the employer can do what he wishes in these matters, but it is difficult to justify large financial expenditures for matters that are of remote, or at least of secondary interest to the factory, especially if the rate of pay is not wholly satisfactory. Educational efforts for the home must be approached with caution by the factory

owner, and religious movements, tho ever so necessary, should never be conducted as a factory activity.

19. *Financial aid.*—No field of employe's service offers such an opportunity as that of aiding the worker to secure a home and protection against want in old age. The worker, as a rule, is lacking in financial acuteness and is a prey, to a large extent, for middlemen and real estate speculators. Not only is an employer justified in assisting his men financially over and above that which goes into the pay envelop, but in some cases he is not discharging his stewardship faithfully unless he does so. This service may be of two kinds, namely, putting his business experience and training at their disposal for assisting them in commercial ventures of their own, or using his financial resources to help in some of their problems of existence.

The most obvious needs of the worker, especially when living costs are mounting, as at present, are cheaper food and clothing and lower rents. Around every factory community grows up a system of middlemen and distributors. It will be readily admitted that such distributors are necessary in some degree, but it is equally true that in most places the system of distribution is extremely expensive. A progressive manufacturer in the middle west found that there was one grocery to every 40 families dependent on his factory, which meant that two or three families besides the wholesalers were making a living of selling and delivering groceries to each average group of 40 fam-

ilies. He has undertaken to solve this problem and reduce the cost of living for his employes by cooperative measures and with good success. The success of this venture depends in no small measure upon the support and guidance of the company.

Of equal importance is the housing problem which has already been touched upon. Many interesting and successful housing plans have been worked out by progressive employers, and the experiences of those concerns who have been compelled to face this problem in connection with the immense new plants built expressly for war supplies during the past two years will prove of great value to those interested in this problem. Briefly, the employer, instead of being interested in stores and lodging houses solely as a source of revenue, may find that it will pay him to study these projects solely with reference to his labor turnover.

Other methods of giving financial assistance to the worker are thru savings and loan associations, insurance plans and similar measures. Any plans that tend to educate the worker in habits of thrift are of especial importance. And lastly there is a fine field of usefulness in assisting the employes to make provision for old age. Many effective pension systems are now in operation, and progressive manufacturers are now advocating that any industry as a whole should care for its old and worn-out employes who have earned such consideration by faithful and long service. It is essential that here, as elsewhere in this

work, no element of patronage should enter, and any financial help offered should be justifiable as a benefit to employers and employes alike.

20. *Recreation.*—It is now conceded, as we have seen, that it pays to provide rest periods for workers; in fact the latest philosophy of management contends that rest periods should be worked out for all kinds of work and that these rests should be compulsory. Rest rooms where women may recuperate from temporary indisposition and rooms where employes may pass the noon hour in recreative pursuits are now quite common and would seem to be justifiable and useful. Many employers, however, have carried the idea of recreation much farther and have introduced systematic recreation into their factories. Miss Mary Barnett Gilson, Employment Superintendent of the Cloth Craft Shops, advocates recreational activities as a real means of training the worker for his place in industry, for promoting ambition and as a means of democratizing the shop and creating not only a sense of fellowship among the workers, but a feeling that he or she "belongs" to the shop; all of which may have some real foundation.

As yet, however, we know very little about the true philosophy of recreation when conducted as a part of employment, and it is obvious that its scope must differ widely. The form of recreation suitable and justifiable for girls doing clean sedentary work will not apply, for instance, to boiler makers or ship-yard workers. There are many occupations indeed in

which it will be exceedingly difficult to introduce diversions, granted that they are desirable, with any assurance of success. There are certain forms of recreation, as shown in the movement to provide at least a short summer vacation for every employe, the usefulness of which cannot be questioned.

21. *Shop athletics.*—The author has always questioned the value of organized shop athletics, shop bands and similar activities that correspond, in a way, to certain activities that appear in connection with our colleges and schools. Even in the last-named institutions these have long been looked upon by some progressive educators as a detriment rather than a real benefit to education. The actual participants in such activities undoubtedly do obtain some special development from them, but their influence upon the student body as a whole is questionable even as far as the fostering of *esprit de corps* is concerned. It would seem that similar arguments apply to shop activities of this kind and it may well be that the benefits derived are wholly imaginary.

Organized social activities may also be questioned. Of course, there are many places where, because of local surroundings, the factory force must depend upon itself for diversions, and no doubt such things as annual picnics and other occasional outings are not only recreative for the workers, but help also, to awaken interest in the work. But the effort so often made to make the factory a social center is at least debatable. The lines of social cleavage in any com-

munity are not those that separate one factory from another. They are curious and intricate always, and are more likely to follow the lines of demarkation laid down by church, fraternal organization or some local social club. The author is not aware of any large number of shop clubs, organized for purely social purposes, that have had a long lease of life.

Much can be done, however, by groups of employes to build up recreative facilities for the entire community. The author holds that it is better for a manufacturing community to have parks and playgrounds open to all and backed by community pride than to have elaborate playgrounds attached to each factory. Play consists partly of change, and the atmosphere of the factory is the atmosphere in which one makes a living. Most of us like to take our recreation away from the office or the factory, and in this respect workers are very much alike.

22. *The future of employes' service.*—It is clear that this work opens up tremendous possibilities for good or evil, and the question naturally arises whither the movement is tending and what it portends. Is it a collection of unrelated items based on personal opinion, experimental in their character, short lived, and of no lasting value? Or is it a part of a greater movement toward the development of a true and satisfactory industrial democracy? Will these experiments in time show us how we shall be able to make an equitable distribution of the proceeds of industry? For, obviously, they are in their essence an

effort to do this very thing. Is this work, in brief, to remain a cheap kind of philanthropy or missionary effort, as it often is, or is it destined to grow into a real service which will be recognized by employer and employe as belonging by right in the field of industrial management? So far as the author is aware, no real comprehensive attempt has been made as yet to analyze this movement with a view of finding its real place in our industrial and social fabric.

23. *The spirit of service.*—These questions would be easier to answer if one were sure of the real motives that lie back of some of these efforts. It must be conceded that much of the welfare work that has been attempted has had selfish motives back of it. Advertising, a hope of distracting discontented employes by athletics, the desire to pose as a benefactor and similar motives have too often been at the bottom of these ventures. Perhaps that is the reason why there have been more failures than successes up to the present time. Even some of those who have entered this field with the highest of motives have met with failure because their work did not rest on solid ground. What, then, is the true foundation of this important work?

Since time began there has been but one common ground on which men could meet and settle their differences equitably and that is the ground of what we call justice. And we may be sure that the time has gone by when men and women will accept any industrial relation on blind faith. Any educational,

religious, recreative, social or other facility provided by any factory management that cannot be justified before the recipients of such privileges, is preordained to fail in this enlightened age. To endure they must be in line with the growth of modern industrial democracy whose watchword is "justice and the square deal." They must rest upon brotherhood and not upon paternalism.

REVIEW

Why is "employes' service" a better designation than "welfare" for the many betterment ideas that employers are carrying out in factories?

Why do employers seek to conserve the health of employes? Is this philanthropy or is it a good investment?

List some of the details to which attention is being paid by wideawake employers in their effort to keep employes well and happy.

Should employers interest themselves in the habits and activities of their employes outside the factory?

If "employes' service" is to accomplish beneficial results, what must be the motive that lies back of their efforts?

CHAPTER XXI

SCIENCE AND MANAGEMENT

1. *Theories of management.*—The foregoing chapters contain a brief discussion of the most important features and theories of modern factory management. Every industrial manager must build up some general plan or philosophy of management if he hopes to succeed. The day of haphazard success has passed away. Naturally the exact combination that will bring success to one man will not produce results for another under different conditions. It would be most difficult to classify and list the particular combinations of personality and equipment necessary for success in all callings. There are, however, certain facts or principles that are universally applicable. Statistics show that 33 per cent of the business failures in the United States are due to lack of capital and that four fifths of the failures are due to incompetence of one kind or another on the part of those failing.

The economic principles of production enumerated in Chapter II, and the applications and extension of these principles as discussed in the succeeding chapters are the most important principles underlying the productive industries. Management is the art of directing these basic principles, as applied thru men and

machines, to some definite result. The question as to how accurately or scientifically these principles can be operated is a natural one. Can management be scientific?

2. *Scientific knowledge.*—To make this matter clear it is necessary to have in mind just what is implied by scientific knowledge and scientific methods and the reader should at this place reread Section 8, Chapter II, with care. It will be clear that the greater part of our knowledge in all lines of endeavor is of the qualitative kind. That is, we know a great deal about the general laws of cause and effect, but comparatively little as to the quantitative character of most phenomena because we have made comparatively few measurements and recorded their results. If Taylor's work has done nothing more, it has brought out clearly how little we know concerning how long it takes to do any operation, what tools are the best, what men are best fitted for the operations in hand, etc.

So far as productive efforts are connected with machines and mechanical processes it is possible, of course, to make fairly accurate computations and predict results with some assurance of success. But when the human element enters, the matter is different. It is generally conceded that division of labor is an economic principle, but we have no data, no recorded results that will show the economic gain derived by various combinations of labor on any one piece of work. In other words, this law is known

qualitatively only, and we are far from being in a position to use it quantitatively. This holds also for such economic principles as coordination of effort that follows from division of labor.

3. *Measurement of human effort.*—When we turn to the problem of measuring human effort in a scientific manner, we are confronted by two diametrically opposed views. The advocates of scientific management, so-called, are quite insistent that this can be done in an accurate manner and that it is possible to compile recorded experience in this field that will serve as a guide in predicting future efforts. Thus Mr. Taylor said: "Scientific Management in its essence, consists of a certain philosophy which results as before stated in a combination of the four great underlying principles of management", which may be briefly formulated as follows:

First—The development of a true science
Second—The scientific selection of the workman
Third—His scientific education and development
Fourth—Intimate friendly cooperation between the management and the men.

And again he stated: "Time and motion study is the accurate scientific method by which the great mass of laws governing movements of men are investigated. . . . They substitute exact knowledge for prejudiced opinion and force in determining all the conditions of work and pay."

In opposition to these bold statements, the late Professor Hoxie, chairman of the committee which made an exhaustive study for the United States Commission on Industrial Relations of thirty-five shops where these new methods have been installed reported: "Far from being the invariable and purely objective matters they are pictured to be, the methods and results of time study and task setting are, in practice, the special sport of individual judgment and opinion, subject to all the possibilities of diversity, inaccuracy, and injustice that arise from human ignorance and prejudice." These equally bold and strong statements naturally raise the question as to the exact status of this highly important matter.

4. *True status of scientific management.*—"Truth usually lies in the middle", and both these views are undoubtedly extreme. There can be no doubt that these modern methods do attack the problems of industrial management in a scientific manner, and for that reason alone they are destined to remain a permanent feature of industry. But at their best they fall short, as yet, of measuring either processes or human efforts accurately enough to furnish true quantitative knowledge. They have already thrown a flood of light upon many features of industry that were considered to be the province of personal administrative ability, and without doubt they will add constantly to our exact knowledge of industrial methods as the years go by. But it will be many, many years, if ever, before the science of management will be reduced

to an exact quantitative basis comparable, for instance, with the science of engineering. Personality will always be a large factor wherever human relations are involved.

5. *Fallacious views.*—The claim so often made by efficiency experts that the introduction of these new methods will surely increase wages universally should be carefully noted because it is fallacious. No doubt it is possible for any individual employer to raise wages because of the introduction of more efficient methods. He could do the same thing by introducing new labor-saving machinery. Labor-saving management and labor-saving machinery are identical in their effects and results. (See Section 7, Chapter VIII.) Without doubt all such methods, in the long run, do benefit all men, but the fact remains that those immediately affected are likely to suffer for the benefit of posterity. Moreover, these ultimate benefits do not flow from any new, inherent principle in these modern methods. They are all simply means of increasing the output of worldly goods and they do not carry with them a single regulative principle that insures the worker his fair share of the added wealth. They in no way affect the laws of distribution of wealth as they now exist, except as they put into the hands of the employer the power, if he will use it, to make a larger pay roll. Just as the introduction of labor-saving machinery has given rise to special legislation and other protective measures, so there is even now appearing such legislative protection against ef-

ficiency methods. This does not mean that these methods will not persist, for they certainly will remain; but it means that their disturbing effects will be permitted to come in by degrees only. Eventually all economic measures appear to obtain recognition.

6. *Selective features.*—It should be remembered also that time study and motion study, functional foremanship, scientific planning of production and particularly the efforts to select men scientifically, actually employ or portend selective agencies such as the world has never seen before. If these agencies are used wisely, they may be of great benefit. If, for instance, they are used as a means of classifying men so as to find out the work for which they are best fitted with a view to developing them to highest efficiency in the walk of life for which nature has endowed them, no criticism can be logically raised.

If, however, these methods are to be used as a means of selecting only the best for industry and of rejecting those that do not rise to a given arbitrary standard, the working classes will have fallen upon evil times. Happily there is little danger of this happening, for labor is too strongly organized to permit it, and employers are too humane, as a rule, to attempt it. In this respect the work of Mr. H. L. Gantt in training men in habits of industry, both as to industrial efficiency and also as to personal thrift, will repay investigation.

7. *The great industrial problem.*—After all, the

sole problem of modern industry is not to see how we can produce more; there is the further task of finding out how we can justly distribute what we have produced. There is an ever growing sentiment that industry should exist for the people and not the people for industry. No one can object to the employer using every legitimate means at his disposal for finding out what he is paying for, and progress can be made only thru these modern methods. Economists compute that as yet we do not produce enough so that all would be cared for as they should be according to modern standards. The employe, therefore, is standing in the way of progress when he refuses to learn new and better methods of doing his work. Usually he will not object if his industrial status is not changed by the new methods but he can hardly be blamed for objecting when it is clear that he is going to be affected adversely by these new methods. We are all afraid of the things we do not understand, and some of these new methods are, therefore, naturally held in distrust by the worker who fears two things as he fears a plague—namely, unemployment and low wages.

8. *Conclusion.*—How shall these problems be met: how shall the worker be assured of employment and the wages of contentment, and how shall the employer be assured of a fair return for his efforts and investments? A discussion of the many ways and means proposed as a remedy for our industrial ills belongs to the wider field of political science. This is indeed

a complex field, filled with abstruse discussion from which the practical man will get little aid without intense study. Politically the remedies proposed lie between the extremes of pure individualism on the one hand and a purely socialistic state of government on the other. We shall probably find a satisfactory adjustment somewhere between the two with perhaps considerable governmental ownership.

The final result of present-day movements will, however, be much affected by what is done in the field of practical management. Here one does not meet so much with philosophical arguments as with dogmatic likes and dislikes, organized resistance, hate and distrust.

It would seem that in this enlightened age much of this could be removed by improved personal relations. Distrust is usually based on selfishness and selfishness is encouraged by lack of knowledge of one another. There are certain forces in our industrial relations that encourage one to believe that this condition could be improved. There are others that make it appear as tho the great questions of management will have to be settled by force. Much can be done to hasten the former solution by employes and employers alike learning forbearance and endeavoring to harmonize their interests. This virtue, it will be noted, is not inherent in any system of management, ancient or modern. We shall be fortunate indeed if some of the influences now at work in our social and industrial organization will point out a peaceful solu-

tion of these problems. If we can so solve them, this democracy will present the greatest opportunity ever offered to humanity. If we cannot solve them, we have no assurance that this republic will endure and its wreckage will surely strew the shores of time along with that of the great civilizations that have gone before.

REVIEW

What is the cause of four-fifths of the business failures which take place in the United States?

State both Mr. Taylor's and Mr. Hoxie's views on scientific management. What is your own deduction concerning the possibility of measuring human effort?

What is meant by the sentiment that industry should exist for the people rather than that the people should exist for industry?

What is the outlook for the future in industrial relations?

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Plant management.

DR. NORMAN A. WIGGINS